ED001635 AN INSTRUCTIONAL GUIDE: MODERN SCIENCE FOR SENIOR HIGH SCHOOLS. Los Angeles City Schools (Los Angeles City Schools, Los Angeles, California). 1963. 195p.

ERIC Document Resume | **See Instruction Sheet** | DATE OF RESUME | DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER ED001635
2. ORIGINATOR CONTROL NO(S). N.A.
3. IDENTIFICATION NO. N.A.

DO NOT WRITE IN SPACE BELOW

MICROFILM COPY AVAILABLE
YES ☒ NO ☐

COPYRIGHT GRANTED
YES ☐ NO ☒

COPYRIGHT RELEASE FILED
YES ☐ NO ☐

TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☐
FINAL ☒
FOLLOW-UP ☐

OTHER ERIC REFERENCES:

ERIC SATELLITE CODE

4. AUTHOR(S): Los Angeles City Schools

5. TITLE OF DOCUMENT ABSTRACTED: An Instructional Guide: Modern Science for Senior High Schools

6. PUBLICATION TITLE: N.A.

7. EDITOR(S): N.A.

8. PLACE OF ORIGIN
ORG. Los Angeles City Schools
ST. CITY, STATE Los Angeles, California
TELE. EXT.
INST/LOC CODE

9. PUBLISHER OR SOURCE
Los Angeles City Schools
Los Angeles, California

10. VOL.	11. PAGES	12. MO./YR.	13. TOTAL PP.
N.A.	N.A.	1963	195

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR curriculum guide

16. INDEXING TERMS (6-12)
teacher education | science; space, sound, electricity, light, chemistry, electronics,
visual aids | [illegible] machines | Los Angeles City Schools
curriculum | general education, modern science, physical sciences

17. ABSTRACT (MAX. 250 WORDS)

Eleven units of study include: Science in Our Lives Today, Applied Chemistry, Modern Materials, Man and Mechanics, Heat and Fuels, Nuclear Energy, Sound, Light, Electricity, Electronics, and Space. All are directed at the student who would use the information gained in everyday life, rather than at the potential science student.

Unit 1 explains the need for science in everyday life, and lists occupations, not requiring college education, that require a scientific interest. The next unit, Chemistry, deals with the basic elements and compounds and their reactions to certain acids and alkali. The use and structure of household cleaning agents are presented as well as the structure of water and foods.

Unit 3 teaches the structure and uses of modern materials such as plastics, textiles, solvents, glass, and metals. Unit 4 includes: simple machines; hydraulic pressure; water systems; air pressure; pulleys, belts and glass; engines and motors; and flight. Unit 5 discusses heat transfer and fuels of various types. In Unit 6, radioactivity is discussed with attention given to the cyclotron. In Unit 7, the transmission of sound is included. The nature of light, color, lenses, and optical instruments, and photography comprise the subject matter of Unit 8. Basic electricity, with application of basic principles to home use is the topic of Unit 9. Unit 10 deals with electronics, vacuum tubes, radio, and television. Unit 11 focuses on space: definitions, vocabulary, space research benefits and the U.S. space program.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION

20. DIVISION OR DEPT.

21. CONTRACT NO.

PROJECT NO.

22. TOTAL COST OF PROJECT

23. DURATION OR PROJECT

U.S. Department of Health,
Education, and Welfare
Office of Education

3

ERIC Form 1

375 D.841 Js.5

Lot

ED001635

AN INSTRUCTIONAL GUIDE
MODERN SCIENCE
FOR SENIOR HIGH SCHOOLS

LOS ANGELES CITY SCHOOLS • 1963

REPRINTED BY PERMISSION
U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN PRINTED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

BLANK PAGE

MODERN SCIENCE

INSTRUCTIONAL GUIDE FOR SENIOR HIGH SCHOOL

LOS ANGELES CITY SCHOOLS
Division of Instructional Services
Publication No. SC-599 • 1963

Educational Materials Laboratory
Office of Education
JUN 1965
DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

This publication was developed in accordance with the Comprehensive Curriculum Policy adopted by the Los Angeles City Board of Education.

APPROVED:

ROBERT E. KELLY
Associate Superintendent
Division of Secondary Education

EVERETT CHAFFEE
Associate Superintendent
Division of Instructional Services

• FOREWORD

Advancement in scientific knowledge has been so great and its impact upon the lives of people so far-reaching that it has become imperative for everyone to understand basic scientific principles and how they affect daily living.

The most costly and serious decisions of local, state, and national governments today cannot be made sensibly without some basis for understanding the scientific aspects of the problems of defense, nuclear energy, medical research, foreign aid, pollution of air, water, soil and growing plants, fallout, the population explosion, the world's capacity to produce food, national drives to conquer disease, and the conquest of space.

Modern Science is a general science course for the citizen. It is designed to make students aware of scientific concepts and problems and of their relationship to the individual's environment in a rapidly developing scientific world.

As understandings are developed in the areas of applied chemistry, modern materials, man and mechanics, nuclear energy, heat and fuels, light, sound, electricity, electronics, and space, it is sincerely hoped that this instructional guide will help the graduating student to achieve the purposes of general education and to meet the challenge of his environment.

EVERETT CHAFFEE
Associate Superintendent
Division of Instructional Services

ACKNOWLEDGMENTS

Development of the Instructional Guide for Modern Science has extended over a period of several years and has involved a number of committees. Appreciation is expressed for the suggestions and work of the members of these groups.

Appreciation is particularly expressed to JOHN McMAHON, Mt. Gleason Junior High School, who developed the experimental edition.

Appreciation is also expressed to GLORIA RICE, Banning High School, who reorganized and edited the guide in its present form.

ARCHIE MacLEAN OWEN
Supervisor of Science
Curriculum Branch

MARY LOUISE JONES
Secondary Curriculum Coordinator

AVERILL M. CHAPMAN
Administrator of Curriculum

Sid Brickman
Washington High School
Raymond Butler
Jordan High School
Jeffry Clark
Taft High School
Herman Doepke
San Fernando High School
Frank Hanna
Wilson High School
Noblesse A. Hill
Jordan High School
Ella Hogan
Hollywood High School
William A. Jones
Jefferson High School
LeRoy W. King
Roosevelt High School
Lily Livingston
Dorsey High School
Warren Miller
No. Hollywood High School
Mae Pattison
Belmont High School
Edward Sacks
Roosevelt High School
Charles Schleiden
Bell High School
Russell Waldo
Cleveland High School
Keith Smith
Division of Secondary Education

• CONTENTS

Page

FOREWORD iii

ACKNOWLEDGMENTS iv

GENERAL EDUCATION AND MODERN SCIENCE 1

MAJOR OBJECTIVES OF MODERN SCIENCE 4

THE STUDENT'S SCIENCE BACKGROUND 5

CONTENT OUTLINE 6

UNITS

1. SCIENCE IN OUR LIVES TODAY 8

2. APPLIED CHEMISTRY 11

3. MODERN MATERIALS 33

4. MAN AND MECHANICS 49

5. HEAT AND FUELS 71

6. NUCLEAR ENERGY 81

7. SOUND 89

8. LIGHT 99

9. ELECTRICITY 113

10. ELECTRONICS 125

11. SPACE 135

APPENDIX

LECTURE-DEMONSTRATION TECHNIQUES 157
USE OF THE LABORATORY 161
SCIENCE LABORATORY REGULATIONS 163
A SAMPLE LABORATORY ACTIVITY 166
SUPPLEMENTARY LABORATORY EXPERIMENTS 1-11 . 171
SUPPLEMENTARY FORMULAS 188

BLANK PAGE

• GENERAL EDUCATIO AND MODERN SCIENCE

MODERN SCIENCE IS DESIGNED TO HELP STUDENTS ACHIEVE MANY OF THE PURPOSES OF GENERAL EDUCATION AS EXPRESSED IN POINT OF VIEW.*

Intellectual Development

The course in Modern Science provides each student with an opportunity to grow in knowledge and skills and to think effectively and critically. Acquiring an understanding of the environment and its effect on people's lives, developing scientific attitudes through understanding what constitutes proof, learning to think logically, interpreting data, using reason and knowledge in arriving at conclusions, and developing intellectual curiosity, open mindedness and flexibility of thought are all necessary parts of a science course designed for citizens in a scientifically oriented culture.

Civic Responsibility

A loyal, informed, participating citizen must recognize the significance of scientific advances for human welfare and acquire the literacy necessary to make intelligent decisions when legislation with scientific aspects is presented.

Economic Competency

Preparing the student for success in a vocation and to be an informed consumer are two important objectives of Modern Science. Other purposes are to develop an awareness of the newly created vocations of the space age and the vast opportunities for everyone as a result of the scientific endeavors of our day; first-hand knowledge of materials, products, and processes by means of demonstrations and laboratory work; and understanding of the need for the proper use and conservation of the material wealth of our world.

---

*Point of View (1961 Revision. Los Angeles City Schools: Publication No. 470).

• GENERAL EDUCATION AND MODERN SCIENCE

Creativity

Modern Science presents the idea that the creative mind of man can meet the challenge of the unknown and solve the unanswered questions of science. Every opportunity is provided to encourage the development of creative thinking in the classroom and laboratory.

Values

To help each person develop high moral, spiritual, and esthetic values, Modern Science emphasizes the individual worth and dignity of man as reflected in scientific achievements. The student is made aware of a power greater than himself as expressed in the energy around him and in the esthetic beauty of natural phenomena. Cooperation, good will, honesty, and responsibility are encouraged as young people work together.

Human Relations

Many of the advances in science today and those of tomorrow are and will be the result of team work, regardless of race, religion, national background, or socio-economic status. Modern Science presents these ideas to young people and provides them with opportunities to work together in the classroom, but still retain individuality, independence of thought, and the ability to act alone.

Health

Physical and mental health are stressed throughout the course in Modern Science. The ability to live in a rapidly changing environment through a greater understanding of the physical world will help each person to realize his full potential as a healthy and mentally well-adjusted human being.

TO ADMINISTRATORS, COUNSELORS, AND TEACHERS

Modern Science is a two-semester course designed for both boys and girls who do not plan to enter a four-year college or university. It will satisfy the graduation requirement for one year of a laboratory science for students who are not pursuing a college preparatory program of studies.

The content of the course develops understandings in areas of physical science, and is planned around activities that are of immediate value to both boys and girls. The teacher should continually orient discussions, demonstrations, and experiments toward student needs.

This instructional guide is organized into self-contained instructional units, with suggested concepts, teacher activities, student activities, audio-visual materials, references, and field trips. Supplementary techniques, laboratory activities, and formulas are listed in an appendix. It is suggested that the sequence of units be followed. The activities and demonstrations described in the guide should be integrated with those presented in the approved textbook and workbook.

Because students need continual practice in using skills of written and oral expression, opportunity is provided for writing about experiments or processes and for making oral explanations. Use of mathematical computations is encouraged. Measuring quantities and distances, collecting data, and making simple graphs to show comparisons are ways of using mathematical knowledge as well as of solving simple arithmetical problems.

The Modern Science course provides excellent opportunities to point up safety practices. Laboratory activities require vigilance on the part of the instructor to assure that safety measures receive first consideration by students. Safety practices should be continuously brought to their attention.

Students who enroll in Modern Science classes learn best through first-hand experiences and use of visual materials. Many learning experiences that require manipulation or observation are suggested in each unit. The teacher is free to plan other or additional activities. It is intended that students have many opportunities to perform experiments, make observations, and draw conclusions from the results of experiments conducted during class laboratory work.

Modern Science classes should contribute to the development of skills in critical thinking. These skills must be directly taught and continuously practiced if students are to learn them thoroughly.

• MAJOR OBJECTIVES OF MODERN SCIENCE

Major objectives of Modern Science are to develop:

An appreciation of how the laws, principles, and concepts of matter and energy are related to an understanding of man's environment.

An understanding of some of the applications of scientific principles in our modern world.

An informed electorate capable of making wise decisions as the result of an increased scientific literacy and an improved method of thinking.

An understanding of how science is changing our environment today through research in industry.

Consumer effectiveness in understanding materials, products, and processes and their application to practical purposes.

Skills in applying scientific methods and critical thinking in solving everyday problems.

Attitudes of intellectual curiosity, open-mindedness, and mental flexibility.

Attention to health and safety practices at school, in the community, and at home.

A laboratory situation in which students may have first-hand experiences.

Skills in accurate observation, in collecting and interpreting data, and in making reasonable conclusions based on facts and logic.

Skills in oral and written communication.

Ability to work together and develop harmonious human relations in a laboratory situation.

A vocabulary which will enable students to understand scientific words used in current writing.

An understanding of the vocational opportunities available to everyone as a result of scientific advancements.

• THE STUDENT'S SCIENCE BACKGROUND

Science 1 (B8)

WAYS OF THE SCIENTIST
What Is Science, Fields of Science, Accuracy of Judgments,
Methods of the Scientist, Tools of the Scientist
BUILDING BLOCKS OF THE UNIVERSE
What Is Matter?, General Properties of Matter, States of Matter,
How Materials Are Put Together, How Matter Can Be Changed,
Physical Changes, Chemical Composition of Matter
AN INTRODUCTION TO LIVING THINGS
Activities of Living Things, Conditions of Life,
Building Blocks of Life, Functions of the Human Body

Science 2 (A8)

MAN AND SPACE
What Our Universe Is Like, What Our Solar System Is Like,
Satellites and Space Travel
OUR CHANGING EARTH
Introduction to Geology, The Earth's Crust,
Forces at Work on the Land, Earth History
INTERRELATIONSHIPS OF LIVING THINGS
Environment and Kinds of Living Things, Structure and Function
of Living Things, Communities of Living Things

Science 3 (B9 or A9)

ENERGY
The Nature of Energy, Structural Relationship of Matter and Energy,
Energy and Wave Lengths
METEOROLOGY
Heat Energy and Weather, Nature of the Atmosphere,
Weather Measurements and Their Use, Greater Weather Patterns
FRONTIERS OF SCIENCE
Oceanography, Exploration of Space, New Developments in Biology

Biology 1 (B10 or A10)

FOUNDATIONS OF LIFE
Chemical Background, Origin of Life, Modern Concept of the Cell,
VARIETY OF LIFE
Basis for Organization, Organization of Living Things,
Variety In Animals, Variety In Plants
DISTRIBUTION OF LIFE
Web of Life, Populations and Communities, Ecological Biogeography
CHANGE AND CONTINUITY OF LIFE
Continuity of Life, Patterns In Heredity, Changes In Living Things

• CONTENT OUTLINE

FIRST SEMESTER

UNIT 1. SCIENCE IN OUR LIVES
    SCIENTIFIC ADVANCES
    EMPLOYMENT OPPORTUNITIES
    METHODS AND TOOLS OF SCIENCE
    MAJOR AREAS TO BE STUDIED

UNIT 2. APPLIED CHEMISTRY
    BASIC CHEMISTRY
    ACIDS, BASES, SALTS
    CLEANERS
    WATER
    FOODS
    BUILDING MATERIALS
    MEDICINES AND COSMETICS

UNIT 3. MODERN MATERIALS
    PLASTICS
    TEXTILES
    METALS

UNIT 4. MAN AND MECHANICS
    FORCE AND MOTION
    FLUIDS
    AIR PRESSURE
    MACHINES
    POWER TRANSMISSION
    ENGINES AND MOTORS
    FLIGHT

UNIT 5. HEAT AND FUELS
    NATURE OF HEAT
    HEAT TRANSFER
    FUELS

UNIT 6. NUCLEAR ENERGY
    STRUCTURE OF MATTER
    RADIOACTIVITY

• CONTENT OUTLINE

SECOND SEMESTER

UNIT 7. SOUND
  NATURE OF SOUND
  MUSIC
  REPRODUCTION AND TRANSMISSION OF SOUND

UNIT 8. LIGHT
  NATURE OF LIGHT
  COLOR
  LENSES AND OPTICAL INSTRUMENTS
  PHOTOGRAPHY

UNIT 9. ELECTRICITY
  BASIC ELECTRICITY
  HOME ELECTRICITY

UNIT 10. ELECTRONICS
  ELECTROSTATICS
  VACUUM TUBES AND SEMI-CONDUCTORS
  RADIO AND TELEVISION
  AUTOMATION

UNIT 11. SPACE
  WHAT IS SPACE?
  PROBLEMS OF SPACE
  BENEFITS OF SPACE RESEARCH
  FUTURE OF SPACE EXPLORATION
  UNITED STATES SPACE PROGRAM
  SPACE VOCABULARY

Unit 1

• SCIENCE IN OUR LIVES TODAY

- **SCIENTIFIC ADVANCES**
- **EMPLOYMENT OPPORTUNITIES**

SCIENCE HAS BECOME A MAJOR PART OF OUR LIVES TODAY.

Concepts and Teaching Suggestions

Advances in science in the last 25 years have changed our daily living.

- Ask class members to list some of the major advances in science during the last 25 years. For example: Atomic power, computers, helicopters, rockets, missiles, satellites, transistors, ultrasonics, radio, astronomy, wonder drugs, plastics, maser, DDT, electron microscope, bionics, and television.
- Show a film illustrating one of the advances in science, such as rockets. See audio-visual material.
- Prepare a bulletin board display of advertisements from Scientific American.
- Discuss science aspects of everyday activities, such as those involved in selecting food, and clothing, watching television, listening to the radio, or driving an automobile.

Science has opened many opportunities for careers and occupations.

- Students prepare lists of occupations involving science interests, but which do not require a college education, such as:

  Television and radio repairmen
  Laboratory helper
  Photographer
  Mechanic
  Telephone repairman
  I. B. M. operator
  Electrician
  Doctor's or dentist's assistant
  Practical nurse
  Food demonstrator

- Discuss and compile a list of desirable traits and skills needed for some of these occupations.
- Discuss science knowledge needed in some occupations, such as those of gasoline station operator or practical nurse.

• METHODS AND TOOLS OF SCIENCE
• MAJOR AREAS TO BE STUDIED

The methods of science include observing accurately, gathering facts, reading what authorities say, experimentation, recording and organizing all necessary material, checking the facts, drawing conclusions from the facts, and being alert for new developments that may change conclusions.

- Select a simple problem of interest to students. Suggest ways that scientific methods could be used in solving the problem.

- Collect examples of advertisements that make extravagant claims. Ask students to analyze them, using scientific methods of critical thinking.

In Modern Science, students will become acquainted with laboratory materials, equipment, and methods.

- Discuss ways of working in the laboratory. (See page 160-162)

- Discuss laboratory regulations and safety precautions. Distribute copies of "Science Safety Regulations." (See page 163-165) Refer to Appendix, "The Use of the Laboratory for Modern Science Classes." (See page 160-162)

- Display and identify for students a variety of pieces of laboratory equipment which will be used in laboratory activities during the semester. Include test tubes, Bunsen burners, flasks, beakers, and tongs.

- Discuss the metric system and methods of measurement in science, including the balance, meter stick, graduate cylinder, and spring balance.

- Discuss some of the vocabulary associated with science.

Modern Science students will study some of the major areas in the physical and chemical worlds.

- Discuss with the class the areas listed in the Content Outline.

- Show some of the new equipment, like the Van DeGraff generator, that will be used during the course.

- Ask students to indicate special interests that they may have in the various science areas.

- Display a number of charts and pieces of science demonstration equipment in the room to stimulate the interest of students.

• TEACHER RESOURCES

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 1. The Metric System of Measurement

Supplementary Laboratory Activity (See Appendix)

Experiment 1. The Science Laboratory page 171

AUDIO-VISUAL MATERIALS

Films*

Fsd 621.3-5	"The Electrician" (occupations)
Fsd 770-4	"Photography" (occupations)
Fsd 610.7-4	"Make Mine Nursing" (occupations)
Fsd 539.76-3	"Jobs in Atomic Energy"
Fsd 621-3	"Mechanical Engineer at Du Pont"
Fsd 152.1-2	"Visual Perception" (scientific)
Fsd 551.11-1	"Project 'Mohole;' Report Number One"
Fsd 658.57-2	"An Equation for Progress"
Fsd 620-2	"American Engineer" (occupations)
Fsd 614.8-45	"Safety in the Chemistry Laboratory"
Fsd 660-8	"A Story of Research"

Filmstrip**

S-2	"The Scientist--His Way, Your Way"

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 1-4.

---

*Refer to Catalog of Films, Secondary Grades. Los Angeles City Schools. (Publication No. 530, 1962 Edition).

**Refer to Catalog of Audio-Visual Materials. Los Angeles City Schools. (Publication No. 579, 1961 Edition).

• APPLIED CHEMISTRY

• BASIC CHEMISTRY

APPLIED CHEMISTRY IS THE PRACTICAL USE OF THE KNOWLEDGE FOR BETTERING OUR ENVIRONMENT THAT MAN HAS GAINED IN THE CHEMICAL LABORATORY.

Concepts and Teaching Suggestions

An understanding of the basic nature of matter is necessary for an understanding of applied chemistry.

- Review the three states of matter: solid, liquid, and gas. Use a piece of ice or a candle to illustrate the three states of matter. Show examples of solids, such as metals, and liquids, such as alcohol. Ignite the gas coming from the bunsen burner.
- Review physical and chemical changes. Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 2, "What Are Chemical and Physical Changes?" may be performed as a teacher demonstration or as a laboratory activity. Simple demonstrations, such as breaking a piece of chalk or burning a match, will illustrate the differences in the types of changes.
- Display a chart of the elements. Review the atomic structure of elements.
- Show examples of elements, such as mercury, iodine, copper, and zinc.
- Discuss the symbols of elements. Administer a brief quiz on the spelling and names of common elements and their symbols.
- Discuss compounds and show examples from the laboratory ($NaCl$, H_2O).
- Refer to Brooks, Tracy, and Tropp. Workbook for Modern Physical Science, 1962 Edition, Experiment 3, "How to Prepare a Mixture and a Compound." Use part of this experiment for classroom demonstration or as a laboratory activity.
- Discuss chemical formulas and show how they are written.
- Show how simple chemical equations are written.
- Show some examples of simple chemical reactions and ask students to write the word equations. (A more advanced group will want to use the symbols and will enjoy balancing the equations.)

• BASIC CHEMISTRY

- Demonstrate the reaction between a salt solution and silver nitrate. Ask a student to write the word equation.

  Sodium chloride + silver nitrate →
  Silver chloride + sodium nitrate (Word equation)

- Dissolve 1 g of silver nitrate in a 500 ml beaker of water. Suspend a piece of aluminum foil in the silver nitrate solution. Crystals of silver will collect on the aluminum until the silver in the silver nitrate has been replaced by aluminum.

  Tin + silver nitrate → silver + tin nitrate (Word equation)

- Prepare a saturated solution of sodium carbonate (washing soda) in one beaker 1/4 full of water. In a second beaker, prepare a saturated solution of calcium chloride. Pour the two together. A precipitate will form.

  Calcium chloride + sodium carbonate →
  Sodium chloride + calcium carbonate (Word equation)

- Discuss and demonstrate types of solutions: dilute, concentrated, saturated, and emulsions.

- Discuss what is meant by physical properties, such as color, density, hardness, and solubility. These may be demonstrated.

• APPLIED CHEMISTR

• ACIDS, BASES, SALTS

ACIDS, BASES, AND SALTS ARE COMMON CHEMICAL COMPOUNDS WHICH ARE USED IN HOME AND INDUSTRY.

Concepts and Teaching Suggestions

Acids and bases have specific characteristics which may make them useful or harmful.

- Show some examples of acids and bases used in the laboratory, such as NaOH and HCl.
- Show their formulas and their reactions to litmus paper.
- Illustrate that acids dissolve some metals. Drop a piece of magnesium ribbon in a beaker containing a small amount of dilute HCl.

Acids are present in some foods, such as citrus and other fruits, vinegar, and sour milk.

- Demonstrate the action of an indicator. See page 9, Brooks, Tracy, and Tropp, Modern Physical Science, Teacher's Manual and Answer Book, 1962 Edition.
- Test various acid foods with such indicators as blue litmus, phenolphthalein, nitrazine paper, and purple cabbage indicator.
- Instruct students to taste various acid-containing foods and to note their typical sour taste.

Some acid foods react with metal containers and should not be stored or cooked in them because the containers may change the flavor of the food or become stained.

- As a classroom demonstration, clean with steel wool and separately weigh on an analytical balance 1" x 2" strips of metal: copper, aluminum, stainless steel, tin, zinc, and iron. Immerse for five days at room temperature in various canned foods, such as tomatoes, milk, vinegar, spinach, meat, and chili sauce. Rinse and reweigh to observe whether some of the metal has reacted with the food. Use the same balance for both measurements. Apply results to the kinds of containers used for storage and cooking of foods. (May be assigned as student activity.)
- Show the inside surface of several types of food cans to note how the metal is coated. (A non-corrosive metal or a lacquer is used.)

• ACIDS, BASES, SALTS

Some bases (alkalies) used in the home are lye, paint removers, oven cleaners, household ammonia, strong soaps, and drain cleaner.

- As a class demonstration, test some of the common household chemicals with indicators for acid or base.

When an acid and base are mixed, they neutralize each other and form a salt.

- Demonstrate the formation of a salt by adding drop by drop a weak solution of HCl to a weak solution of phenolphthalein. Evaporate the solution in an evaporating dish and cautiously taste the residue.
- Demonstrate the use of burettes in the careful neutralization of acid and base. This will also introduce a neutralization experiment done by the students in the laboratory. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 10.
- Present several other common salts used in the laboratory and discuss their uses. Common NaCl is a good example to discuss, since the two elements of which it is composed are a highly active metal (sodium) and a poison gas (chlorine). Baking soda and epsom salts are two other common salts.

Acids may act on certain salts to produce a gas.

- Hold a test tube half filled with vinegar over a sink. Add half a teaspoon of baking soda. Discuss why baking soda is used when sour milk or vinegar is in a recipe.
- Put equal amounts of baking soda and double-acting baking powder in separate test tubes of water. Compare to observe speed with which CO_2 is released as heat is slowly applied by means of a hot water bath.
- Point out uses of baking powder. Introduce the experiment on baking powder. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 16.

There are some bases and acids that are very damaging to flesh.

- As a class demonstration, place two small pieces of meat and bone in each of three test tubes. One test tube will contain 10 ml of water, the second 10 ml of NaOH, and the third 10 ml of HCl. Observe after 24 hours. Compare with control samples in water.

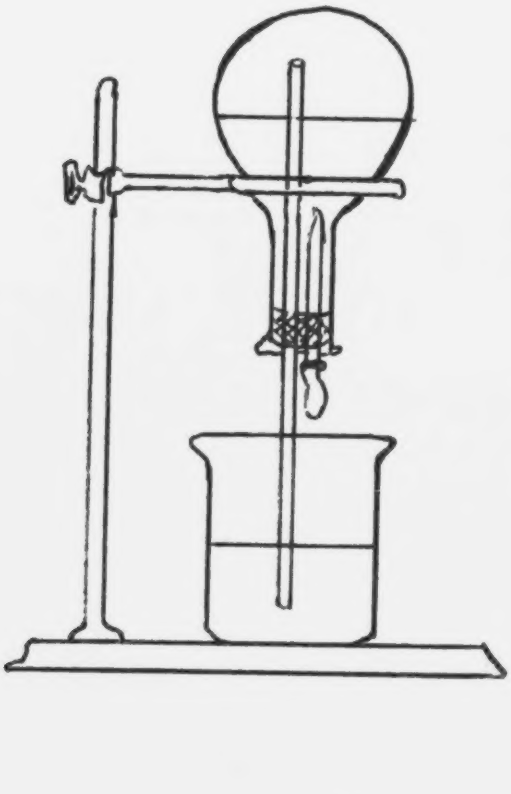
- Relate the caustic properties of bases to the use of lye and ammonia as cleaning agents.
- Discuss first aid for chemical burns and poisoning, using latest edition of American Red Cross First Aid Textbook.
- Using indicators, test the relative amount of a base in different brands of laundry and facial soaps. Relate the use of these soaps and their effect upon the skin.

Make an ammonia fountain to illustrate the ability of ammonia to dissolve in water, forming a base. This may be used as an enrichment activity.

Make ammonia gas by heating CaO and NH_4Cl. This gas can be collected by downward displacement of air in a large dry flask.

Fit a 12-inch piece of dry glass tubing and a medicine dropper completely filled with water (outside dry) into a two-hole rubber stopper. Insert the stopper into the inverted flask of NH_3 gas. Place the glass tubing into a beaker of water containing phenophthalein. Squeeze the bulb of the medicine dropper and squirt a little water into the top of the inverted flask.

Hint: Pour 2 or 3 ml of ether over top of flask to start ammonia fountain.



- **CLEANERS**

CLEANERS, INCLUDING SOAPS AND DETERGENTS, ARE COMMON HOUSEHOLD CHEMICALS.

Concepts and Teaching Suggestions

Soaps or synthetic detergents reduce the surface tension of fluid surfaces and emulsify the oils and dirt.

- Demonstrate surface tension and emulsification:

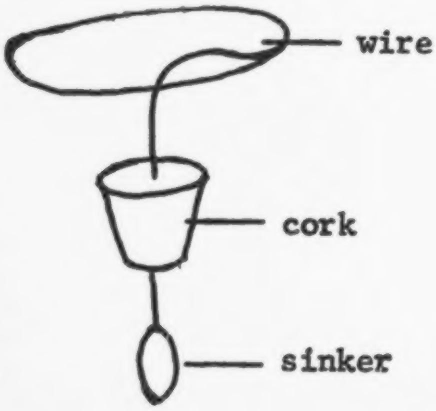
  Fill a glass with water. Permit the water to run over the edge of the glass by dropping small nails into the water. Add one drop of liquid soap and note what happens as the surface tension is reduced by the soap.

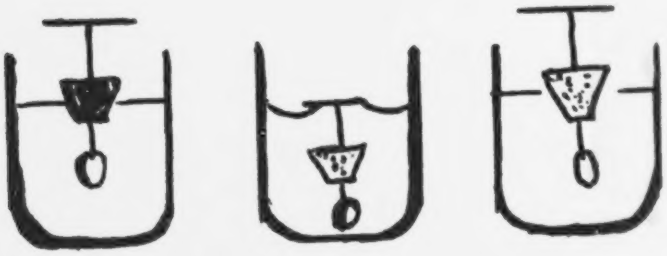
  Dip the wooden end of a match stick in soap and then float it in water. Surface tension is reduced on the soap end.

  Float a little kerosene on water and notice the action of detergent as a few drops are added at the center.

  Float a dry needle or razor blade on water. Notice how water is indented around the object. Add one drop of a liquid soap or detergent. Surface tension is reduced.

- Demonstrate surface tension apparatus.





  The sinker should be heavy enough to drag the wire below the surface of the water in a battery jar. Then peel off pieces of lead from the sinker until the surface tension of the water will just keep the apparatus from bobbing up. Add a few drops of liquid soap to cause the apparatus to bob up. Cork should be coated with fingernail polish.

Soap is made as a result of the action between an alkaline (base) and organic oil or fat.

• APPLIED CHEMISTRY

• CLEANERS

Synthetic detergents are more effective cleansing agents than soap. The purpose of the soap or detergent is to hold the grease in suspension.

- Demonstrate the action of a synthetic detergent and then compare it with that of soap in a weak acid solution and a weak base solution, using first distilled water and then water containing a little kerosene. Examine the result by passing a light through the liquid. Also examine test tube after removing liquid for cleanliness.

  Using a pure soap, make an inch of suds in a flask 1/4 full of water. Add diluted detergent, a drop at a time, to observe what action it has on suds.

  Test the ability of various soaps and detergents to emulsify, using 20 cc kerosene, 20 cc water, and 10 ml soap solution or detergent solution (equivalent dilutions).

• WATER

WATER IS A BASIC HOUSEHOLD NECESSITY FOR CLEANING, COOKING, AND OTHER IMPORTANT USES.

Concepts and Teaching Suggestions

Water must be supplied in a potable state to the household.

- Demonstrate some of the basic steps in producing potable water. Include settling, settling with chemicals, and filtering.

  Use two beakers containing water in which mud has been stirred. Allow to settle normally. To one beaker, add alum and lime (aluminum sulfate and calcium hydroxide). Observe the jelly-like precipitate which clears the water. Compare with content of the first beaker.

- Show a cross section of a sand filter. Discuss purpose of each layer. See Brooks, Tracy, and Tropp, Modern Physical Science, 1962 Edition, page 117. Discuss aeration and chlorination as additional steps in water treatment.

- Demonstrate water purification by distillation. Refer to Experiment 14, "How to Purify Water," Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition.

- Discuss the problems of desalting sea water by distillation or other methods.

In many communities, hard water is a problem because it forms scale on the inside of hot water pipes.

- Display the cross section of a pipe from an old water heater to point out the scaly deposit. Test with HCl to observe how much $CaCO_3$ is present in the deposit.

- Scrape the "boiler scale" from the bottom of a teakettle. Find out how much water must be evaporated to form that scale. This can be approximated by determining the increase in weight of an evaporating dish when a known amount of water is evaporated from it. Use the analytical balance. (May be assigned as student activity.)

Soaps in hard water form insoluble greasy substances.

- Using medicine dropper, compare the amount of soap solution (2% green soap) required to produce 1 inch of suds on 30 ml of each of the following: distilled water, tap water, zeolite or permutite softened water, and chemically hardened water. Use a small amount of calcium phosphate or magnesium sulfate.

Synthetic detergents form soluble salts in hard water.

- Compare the action of a detergent to the action of a soap on hard water, on distilled water, and on tap water.

• FOODS

A KNOWLEDGE OF CHEMISTRY IS AN IMPORTANT PART OF UNDERSTANDING FOODS AND COOKING.

Concepts and Teaching Suggestions

Some very simple tests can be made on foods to discover their composition.

- Test various foods, such as bread, corn syrup, meat, egg white, and corn meal for starch, sugar, protein, and fat.

- To test for the presence of starch, add a few drops of iodine to cooked starch. (A dark blue-black color indicates starch.) Hydrolyze starch by adding a few drops of HCl to starch solution and warm in water bath. Conduct sugar and starch tests separately.

- Extract starch from potatoes. First grate peeled, uncooked potato into a dish of water. Wash the grater and allow this water to drop into the same dish. Strain the contents of the dish through a filter made of several folds of cheesecloth. Wash the material on the cheesecloth with still more water. Shake the material which passed through the filter. Let it stand in a large test tube for 10 minutes. Pour off the water. The solid left is starch. Boil some of this potato starch in a test tube. Cool it. Then add 1 drop of iodine solution.

- Find the composition of an unknown by testing for starch, sugar, and protein. (Powdered milk with a little cornstarch added can be used for this purpose.)

- To test for the presence of simple sugar, add 3 ml each of Fehling's solutions A and B, or 3 ml of Benedict's solution, to 5 ml of solution to be tested. Heat almost to boiling. Brick red color indicates a reducing sugar. Caution: Watch liquid. Boils over easily.

- To test for presence of protein, add 2 drops of concentrated nitric acid to the substance to be tested (egg white). Heat gently until yellow color appears. Cool, and then add 2 drops of ammonium hydroxide. An orange color indicates presence of a protein.

- To test for presence of fats and oils, shake food sample with 5 ml of ether, chloroform, or benzene in a well-ventilated room. Filter. Put filtrate in watch glass to evaporate. It will feel oily. Another test is to rub the food on brown paper. Foods containing fats or oils leave an oil spot that will not dry.

- To test for presence of water, weigh a portion of food. Dry it by heating slowly with a minimum of scorching. Weigh again. Calculate the percentage of water.

Many foods are diluted or adulterated with cheaper substances, such as starch and water.

- Discuss adulteration of commercial foods.

- Demonstrate several experiments, see Experiment No. 7, Laboratory Activities, page 180.

- Discuss the value of having some foods diluted when purchased, such as acetic acid (vinegar) and food flavorings.

- Show labels of various brands of the same product which show percentages of adulterants. (Examples may include instant coffee, baking powder, vinegar, and packaged luncheon meats.) Test sausage, "hot dogs," and luncheon meats for starch. (Be sure to select a brand that contains starch.)

- Test for caffeine in coffee. Put a teaspoon of instant coffee in 200 ml boiling water. Cool and add 10 cc chloroform and shake for 2 minutes. Allow chloroform to settle to bottom. Remove just the chloroform with a medicine dropper and place in a clean evaporating dish. Pour 95% ethyl alcohol on the residue and pour this on a clean watch glass. Residue that remains is caffeine.

Chemicals may be used to preserve foods.

- Point out to the class that the labels on dried fruits, canned fruits, and vegetables show chemical preservatives and seasonings.

  Sulphur dioxide is a preservative and bleach for dried fruits.
  Benzoate of soda is a preservative in maraschino cherries.
  Chili saltpeter (KNO_3) is a preservative in meat products.

- **FOODS**

Bread is kept fresh with mono glycerides, which are also classed as shortening and hence need not be listed on the label.

- Note quantities of preservatives used on labels of canned products.

The cooking of foods involves chemistry.*

The more sugar that is dissolved in water, the higher will be the boiling point of the solution. Test the stages of boiling sugar.

- Dissolve 100 gm sugar in 60 ml hot water. Use a 250 ml beaker. Suspend a thermometer in the solution so it does not touch the bottom of the beaker. Heat and record temperature at which water boils. Wipe off crystals that may form on the sides of the beaker. When solution reaches 105°C, put a few drops of the solution in a watch glass. Ask the class to record the temperature of the soft-ball, hard-ball, and brittle stages.

  Discuss the reason for the increasing boiling point of the solution.

Sugar crystals may form from a supersaturated sugar solution into which foreign matter is introduced.

- Prepare 200 ml of a supersaturated solution of sugar in a 250 ml flask. With a thread, hang a paper clip in the solution. Allow the solution to remain undisturbed for a number of days. Ask the class to observe the growth of the crystals.

---

*Experiments may be performed as teacher demonstrations, or as individual or class experiments.

• APPLIED CHEMISTRY

• FOODS

Crystallization can be controlled by retarding crystal growth and decreasing evaporation.

- Make fudge in the classroom. Using a low flame, heat to scalding 40 ml of milk in a 500 ml beaker. Cut a half square of chocolate and add to the milk. Add 102 gm of cane sugar and 10 ml of light corn syrup (Karo). When the chocolate has melted, stir the mixture until the sugar dissolves.

  When mixture boils, cover with a large waterglass. Continue cooking to 115°C (softball). Remove from flame and place a teaspoon of butter around the inside of the beaker, but do not stir it into the fudge.

  Pour half of the mixture into another beaker; beat it vigorously while hot and pour into a muffin cup. Set the remainder aside to cool (45°C - 55°C). Then beat it vigorously until it is thick; then pour the mixture into muffin cups. Place one cup in a sealed can, leave one in the air, place one in the refrigerator.

  On the following day, ask the class to compare the texture of crystallization of the fudge samples. Suggest that students try some of these tests at home and bring results to class.

Many prepared products have resulted from careful chemical testing in food laboratories.

- Point out various labels on prepared foods, such as cake mixes. Discuss why directions on the box should be carefully followed.

- Cook frozen peas. Follow directions carefully in cooking one half of the contents of the box. For the other half, prepare without care, by using too much water. Instruct class to compare results. Discuss quality, flavor, texture, and vitamin content of resulting products.

Cheese and butter are two important products made by chemical processes.

- Make cheese in the classroom. To 1 quart of skim milk, add a rennet tablet that has been dissolved in 5 ml of warm water. Heat the mixture to 70°C. After 15 minutes, stir the mixture, and allow milk to separate into curds (casein) and whey. Strain through cheesecloth. The remainder is cottage cheese.

- **FOODS**

  - Make sweet butter in the classroom. Add 4 or 5 drops of lactic acid to 1/2 pint of cream. Let the mixture stand 15 minutes. Shake till lumps of fat form. Pour off the liquid and wash fat with cold fresh water.

Emulsifying agents will make oil and water mix in salad dressings.

  - In each of 4 test tubes, place water, dilute soap solution, starch solution, and egg white diluted with equal amounts of water. Add 3 drops of cottonseed oil to each test tube and shake vigorously. Note which remains mixed.

  - Make mayonnaise. Pour 30 ml of cooking oil and 15 ml of vinegar into a beaker. Shake vigorously. Separate into two portions. Add a few ml of egg yolk to one portion and shake again. Observe if separation takes place.

Proper cooking temperatures are of importance in obtaining foods of good texture and quality.

  - Place one egg in boiling water for 3 minutes. Place another in cold water and heat till water comes to a rolling boil. The second method will cause an egg to be soft in texture.

  - Discuss other cases in which temperature is important, such as the temperature of cooking oils in frying foods or in the absorption of fat.

Manufacturers of food products use weight instead of volume measurement in making food products.

  - Sift an equal amount of 2 brands of flour several times. Measure 1 cup of each. Weigh both cups. Compare weight.

  - Discuss why weighing is more accurate than volume measurement.

• APPLIED CHEMISTR

• BUILDING MATERIALS

THE PROPER USE OF BUILDING MATERIALS INVOLVES SOME KNOWLEDGE OF CHEMISTRY.

Concepts and Teaching Suggestions

Use of building materials involves a number of chemical reactions.

- Show examples of building materials, such as cement, plaster, ceramic tile, and bricks.
- Slake some lime.
  Calcium oxide + water → calcium hydroxide
- Mix some mortar.
  Sand + calcium hydroxide + water. Make a small brick of this material.
- Explain how plaster is a mixture of mortar and plaster of Paris. Make some plaster.
- Discuss the manufacture of cement. Make a brick from cement.
- Make a tile with ceramic clay. Discuss the firing of clay.
- Show various examples of oil paint, varnish, enamel, lacquers, and rubber-base paint. Obtain samples from a paint store.
- Discuss the composition of the above paints.
- Show the ingredients of an oil paint (linseed), drying oil, pigment (zinc oxide), thinner (turpentine), and drying agent. Mix a paint in the laboratory.
- Discuss the advantages of rubber-base paints.

• MEDICINES AND COSMETICS

MEDICINES AND COSMETICS ARE EXAMPLES OF APPLIED CHEMICAL KNOWLEDGE.

Concepts and Teaching Suggestions

The medicine chest contains many chemicals which require care with regard to the quantity used.

- Ask students to list all substances located in the medicine cabinet at home and to organize them into groups, such as disinfectants, antiseptics, headache remedies, prescriptions, and others.
- Point out that careful examination will indicate some prescriptions and other outdated substances that should be discarded.
- Discuss the similarity in appearance of some of these drugs.
- Prepare a typical household medicine, such as tincture of iodine. Add a tiny crystal of iodine to 10 ml of alcohol.
- Display typical medicines contained in medicine chest and emphasize the importance of reading labels as to ingredients and proper dosage.

Cosmetics and dentrifices have simple basic formulas and are easily made in the laboratory.

- Demonstrate the making of a cosmetic, such as cold cream. See Appendix, page 179.
- See supplementary cosmetic formulas, pages 188-189.
- Discuss advertising claims for cosmetics.

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 2. What Are Chemical and Physical Changes?
" 3. How to Prepare a Mixture and a Compound
" 8. What Are Acids Like?
" 9. How Do Bases Act?
" 10. What Happens When You Mix an Acid and a Base?
" 11. Table Salt Comes from Crude Rock Salt
" 12. Making Solutions and Getting Crystals
" 14. How to Purify Water: Distillation
" 15. How to Make Soap
" 16. How You Can Make Baking Powder
" 17. How You Can Make Cold Cream
" 18. How Builders Make Mortar
" 19. How You Can Make Paint

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

Supplementary Laboratory Activities (See Appendix)

Experiment	2.	Elements and Compounds	page 173
"	3.	Properties of Acids and Bases	page 174
"	4.	Distillation of Water	page 176
"	5.	Clarification of Water	page 178
"	6.	Preparing a Simple Cosmetic	page 179
"	7.	Food Adulteration	page 180

• TEACHER RESOURCES

REPORTS

Suggested Titles

Atoms and Molecules

Acids and Bases in the Household

Detergents or Syndets

Paint Today

The Cement Industry

The Purpose and Quantity of Detergent in Motor Oil

Minerals Found in Sea Water

Water Softeners

Synthesizing of Drugs

Antibiotics and the Need for Following the Doctor's Instructions in Their Use

Chemistry and Biology Involved in the Use of Disinfectants, Antiseptics, Laxatives, and Other Products

Making Fresh Water From Sea Water

Water Purification in the Community

PROJECTS

Collect labels of various brands of the same kind of food. Discuss labeling of foods as required by pure food and drug laws. Analyze labels in terms of these requirements.

Visit a bakery. Find out the types of preservatives and fresheners that are used in bread.

Report on preservation of food with atomic radiation.

Investigate the pure food and drug laws and public health laws to learn about restrictions on use of chemical preservatives.

Grow crystals from supersaturated solutions.

Collect samples of building materials. Describe their characteristics and uses.

Make various cosmetics at home. Note cost of ingredients and other data.

Collect examples of elements.

Make models of atoms, using beads.

Test household acids and bases, using an indicator of shredded purple cabbage.

Collect samples of various paints available on the market today. Examine the labels for chemical composition. Compare them.

Collect samples of various household chemicals. Find out what their chemical formulas are, whether they are acids or bases, and their uses in the household.

• TEACHER RESOURCES

AUDIO-VISUAL MATERIALS

Films*

Fsd 541.2-13	"A Is for Atom"
Fsd 541.39-1	"Chemical Change"
Fsd 691.7-2	"Corrosion"
Fsd 540-1	"Introduction to Chemistry"
Fsd 660-10	"Pattern for Chemicals"
Fsd 540-3	"Preface to Chemistry"
Fsd 539-1	"Our Friend, the Atom"
Fsd 648.1-4	"Soft as a Cloud"
Fsd 668.1-1	"Detergents From Petroleum"
Fsd 698.1-2	"The Way of What Happens to Paint" - Exterior Painting
Fsd 698.1-1	"The Way of What Happens to Paint" - Interior Painting
Fsd 614.84-11	"A Way With Fires"
Fsd 691.4-1	"Brick Is Modern"
Fsd 693.5-1	"Let's Make Concrete"
Fsd 628.1-13	"Pipeline to the Clouds" (water supply)
Fsd 676-4	"Paper"
Fsd 615.1-3	"And the Earth Shall Give Back Life"
Fsd 664.8-6	"Frozen Freshness"
Fsd 664.8-9	"Why Food Spoils"
Fsd 664.8-1	"Yesterday, Today, and Tomorrow" (canning)

Filmstrips**

S-66	"Acid and Basic Solutions"
S 104	"What Are Elements and Compounds?"
S 91	"What Is Chemistry?"
S 67	"Electrolysis"
VE 46	"The Wonders of Paint"
VE 4	"Home Repair Series" (Sets 5 and 6,"Painting in the Home")
No 147	"The Secret of Hot Water Magic"
S 46	"Putting Electrolysis to Work"
S 44	"Air Age Physics--Matter and Molecules" (Sets 1-6)
S 36	"Making Water Safe To Drink"
S 92	"Water Purification"
HE 43	"Cooking Series" (8 Filmstrips) "Buying Food Wisely"
HE 43	"Cooking Series" (8 Filmstrips) "Storing Foods"

---

*Refer to Catalog of Films, Secondary Grades. Los Angeles City Schools. (Publication No. 530, 1962 Edition).

**Refer to Catalog of Audio-Visual Materials. Los Angeles City Schools. (Publication No. 579, 1961 Edition).

FIELD TRIPS

Refer to It's Worth a Visit, Catalog of School Journeys. Los Angeles City Schools. Publication No. SC-460, 1960 Edition.

Follow instructions as outlined in the publication for planning school journeys.

The trips listed below would be of value to modern science students.

Arden Farms Company (Creamery)
103 S. Hamel Road
Los Angeles

Barbara Ann Baking Company
3545 Pasadena Avenue
Los Angeles

Helms Bakery
8800 Venice Boulevard
Los Angeles

Safeway Stores Inc.
6175 E. Slauson Avenue
Los Angeles

- **TEACHER RESOURCES**

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 10-35, 109-145.

GENERAL REFERENCES (For teachers)

Joseph, Brandwein, Morholt, Pollock, and Castka. A Sourcebook for the Physical Sciences. New York: Harcourt, Brace and World, 1961.

Dull, Metcalfe, and Williams. Modern Chemistry. New York: Holt, Rinehart, and Winston

Brinckerhoff, Cross, Watson, and Brandwein. The Physical World. New York: Harcourt-Brace, 1958.

Using Chemicals. Bureau of Secondary Curriculum Development, New York State Department of Education

Practice of Pharmacy, 11th Edition. New York: Remington's, 1956. pp. 163-164.

New Practical Pharmacy. New York: Chemical Publishing Co., 1955.

Brooks, Tracy, and Tropp. Modern Physical Science, Teacher's Manual and Answer Book. New York: Holt, Rinehart, and Winston, 1962.

• MODERN MATERIALS

• PLASTICS

THROUGH THE RESULTS OF SCIENTIFIC RESEARCH, PLASTICS, TEXTILES, AND METALS HAVE DEVELOPED INTO MODERN MATERIALS WHICH HAVE REVOLUTIONIZED MAN'S ENVIRONMENT.

Concepts and Teaching Suggestions

Plastics made from synthetic resins have contributed to many phases of modern life.

- Exhibit various articles made of plastic materials taken from the kitchen, classroom, and shop.
- Discuss ways in which plastics have been substituted for other materials.

Plastics are composed of giant molecules called polymers.

- If materials are available, show the process of polymerization.
- Demonstrate the action of "silly putty," which can be bounced like a ball, pulled into a long string, or shattered with a hammer.
- Show a diagram, model, or chart of a giant molecule.

Plastics are varied in nature and exhibit a number of differences in properties which make them adaptable for many uses.

- Demonstrate the properties of plastics, such as flexibility, hardness, and resistance to scratching.
- Show examples of acrylics, Bakelite, polystyrene, silicones, and vinyl.
- Demonstrate means of identifying plastics by flame and odor method. See Appendix, pp. 181-182.
- Test various types of plastics in solvents. Some thermosetting plastics dissolve in ethyl alcohol. Some thermoplastics dissolve in acetone. Cellulose acetate dissolves in half ether and half alcohol. Caution: Keep solvents away from flame and the room well ventilated.
- Demonstrate the difference between a thermoplastic and thermosetting plastic by burning. Thermoplastic bends on heating. Thermosetting types assume a permanent shape and will not bend on heating.

• PLASTICS

Plastic articles are made by compression, extrusion, injection, and vacuum forming.

- Exhibit charts or blackboard drawings of the above methods. Show articles produced by compression, extrusion, or injection.

Plastics are synthetic materials made in the laboratory.

- Prepare a casein plastic. Heat fresh skim milk to 37°C and add rennet (see label for quantity) to coagulate in 15-20 minutes. Pour off whey and wash curd with water several times. Wash with alcohol, then ether; wash with acetone and dry. Grind to a fine powder. Mix with 30-40% water and let stand 1 hour or in the refrigerator overnight. Shape into a rod and heat to 180°C. Harden in formaldehyde bath and dry. (This may be assigned as a student project.)

- As a demonstration, embed a small object in clear plastic. See References for Plastics on page 48 for directions.

- Prepare a phenolic plastic like Bakelite. Pour 100 cc of a saturated solution of aniline hydrochloride (if available) and 100 cc of 40% formaldehyde simultaneously into a 300 cc beaker. A thick dark brown mass will form, which upon hardening resembles Bakelite.

Rubber is an important polymer.

- Add dilute acetic acid to latex in a beaker. Stir the mixture with a stirring rod until the rubber forms a ball. If raw latex is unavailable, use some rubber-base paint or a liquid rubber compound used for making molds (e.g., pliaflex available from Fry Plastics).

- Demonstrate various properties of rubber. Note elasticity and brittleness when rubber is cooled or frozen.

Vulcanization is a necessary process in rubber production.

- Vulcanize an automobile tire patch on a piece of rubber inner tube. Compare to a cemented patch, which can be removed more easily.

Rubber tires are reinforced with various materials.

- **Show cross section of various tires. Point out ply, beading, rayon and nylon reinforcement, and depth of tread.**

Glass is a plastic.

- **Discuss the composition of glass and its uses.**
- **Make a bead of borax glass. Place a small loop in the end of a platinum wire. Heat the loop in a Bunsen flame. Dip it in borax and heat the loop until a drop forms. This is a kind of borax glass.**
- **Heat the middle of a piece of glass tubing. When the glass becomes plastic, pull the ends of the tube and draw the glass out into a long filament. Break the filament when it has cooled.**

• TEXTILES

TEXTILES AND TEXTILE FIBERS INCLUDE BOTH NATURAL AND SYNTHETIC TYPES. THE SYNTHETIC FIBERS ARE REPLACING OR SUPPLEMENTING THE NATURAL FIBERS.

Concepts and Teaching Suggestions

A number of varieties of new textiles are making their appearance.

- Display samples of natural and synthetic fibers, such as wool, silk, nylon, orlon, rayon, acrilon, Velon, Dacron, and Saran.

Synthetic fibers are made by laboratory methods.

- Demonstrate the making of rayon by the cupramonium process. Add ammonium hydroxide to a copper sulphate solution. A green precipitate will form. Filter the solution. Place the filter paper with the precipitate in a beaker and add ammonium hydroxide. More filter paper may be added to the solution. After the mixture stands for a few hours, it will become syrupy as the cellulose in the filter paper breaks down. Fill an eye dropper with some of the syrupy mixture. Squeeze into dilute sulfuric acid (5%). A rayon strand will form. Caution: The room must be well ventilated. Use fume hood if available.

Various burning and chemical tests can help identify textiles.

- Test textiles by means of chemicals. Place samples of wool, silk, cotton, linen, nylon, and other textiles in separate pyrex test tubes. Add a 5% solution of NaOH. Boil gently for 10 minutes. Wool, silk, Aralac, and Dacron will dissolve. Cotton, rayon, linen, and nylon will not dissolve. Addition of lead acetate to the solution will identify wool. The sulfur in the wool will cause the solution to turn black. This does not happen with silk.

- Test various materials in the laboratory by burning. Hold fibers in flame and compare the way in which they burn.

Chart for Textile Identification by Means of Flame Tests

TYPE OF TEXTILE	RESULTS OF BURNING
Acetate	Shrinks from flame. Forms irregular dark bead which crumbles between fingers when cooled.
Cotton	Does not shrink from flame. No bead. Fine, soft gray ash.
Flax (linen)	Odor of burning paper.
Dacron	Fiber shrinks to form bead. Difficult to crush when cool. Dark, sooty smoke.
Nylon	Shrinks to form round bead. Difficult to crush when cool. White smoke, not sooty. Chemical odor.
Orlon	Like acetate, but has characteristic odor.
Rayon (viscose)	Like cotton.
Silk	Does not shrink from flame. Soft, fluffy knob forms. Odor of burning feathers or hair. Black, crushable ash.
Wool	Same as silk, but burns slowly. Black, crushable ash.
Fiberglass and asbestos	Do not burn.

(Caution: Have fire extinguisher available.)

For student laboratory experiments, see Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 20, "What Are the Natural Fibers?" Above identification chart may be duplicated and used as a reference during class experiment.

- **TEXTILES**

Thread count is an indication of the weaving quality of cotton fabrics.

- Demonstrate how thread count can be determined with a magnifying glass and ruler.

Fabric	Yarns/Inch Warp Woof	% Sizing
Percale	104 x 98	1.0
Fine count muslin	84 x 80	1.0
Heavy weight muslin	74 x 66	2.0
Medium weight muslin	68 x 60	5.0
Light weight muslin	56 x 56	8.5

Sizing is a substance which makes a material stiff and also makes it appear stronger.

- Demonstrate how to determine the amount of sizing in a material. Weigh sample. Remove sizing by boiling in 5% oxalic acid for 10 minutes or 1% HCl for 5 minutes. Rinse, dry, and reweigh. See above scale for per cent of sizing.

Some textiles shrink more than others.

- Compare shrinkage by using different samples of cotton and wool of the same size (8" sq.). Use both sanforized and unsanforized materials. Wash and dry. Do not stretch or wring out. Iron lightly without rubbing. Iron across material. Compare to original size.

Bleaching is a chemical process used in the textile industry.

- Bleach some cotton cloth with chlorine. In a tall glass cylinder, place a teaspoon of chloride of lime (bleaching powder). Pour in 10 ml of concentrated HCl. Place wet cotton cloth in fumes. Cover and leave in cylinder for about 45 minutes. Caution: Chlorine is a poisonous gas. Use fume hood. Bleach with sulfur dioxide. Burn a little sulfur in the bottom of a glass cylinder. Insert a wet colored flower. Examine after 20 minutes and note color changes. (Sulfur dioxide is a bleach for animal fibers.) Try bleaching a piece of wool in the fumes.

Dyes are classified by their means of application. Direct dyeing and mordant dyeing are two types of application.

- **Dye samples of cotton cloth (6" sq.). Remove sizing from cotton by boiling gently in 1% HCl for 5 minutes, or 5% oxalic acid for 10 minutes.**

  Mordant samples of the material by boiling in 5% aluminum sulfate for 3 minutes. Remove samples and squeeze out excess liquid. Place in dilute ammonium hydroxide (1:15) and warm for 3 minutes. Thoroughly rinse in cold water and press out to dry.

  Dye samples of material, both mordanted and unmordanted, with congo red, malachite green, and alyzarin. Dye suspension is 0.25 grams of alyzarin to 50 cc of water. Place 2 samples in 25 ml of the dye and boil gently for 3 minutes. Thoroughly rinse in cold water and press out to dry.*

---

*For additional suggestions for textile tests and dyeing techniques, refer to Joseph, et al. A Sourcebook for the Physical Sciences, pp. 304-308.

- METALS

METALS ARE SOMETIMES SAID TO BE THE BACKBONE OF CIVILIZATION. MOST METALS USED TODAY DO NOT OCCUR NATURALLY IN THE EARTH NOR ARE THEY USED DIRECTLY FROM REFINED ORES. THEY ARE COMBINATIONS OF OTHER METALS OR OF METALS AND NON-METALLIC ELEMENTS. THESE MATERIALS ARE CALLED "ALLOYS." METALLURGISTS MEETING THE DEMANDS OF THE SPACE AGE ARE CREATING MANY NEW ALLOYS FOR NEW PURPOSES.

Concepts and Teaching Suggestions

More than 70 of the 92 natural elements are metals. They have a number of different properties.

- Display samples of various metals and compare their properties. For example, show relatively inert copper and silver, liquid mercury, and highly active sodium (which must be stored in kerosene). Caution: Teacher must perform demonstration.
- Illustrate some chemical properties of various metals, such as the rusting of iron. Demonstrate reactions of various metals to acid. Place zinc in acid to show that a gas is given off.
- Demonstrate some of the physical properties of metals. Use a conductometer, if available, to show conduction of metals.
- Use a ball and ring expansion apparatus and compound bar to illustrate contraction and expansion of metals.

More iron and steel are used in the United States than any other metals.

- Show kit, filmstrip, or films referred to in Audio-Visual Materials, page 46.
- Display charts of a blast furnace and a flowchart of steel production.

Metals may be shaped into many forms. Consequently, it is possible to use them in many fabrication operations.

- Demonstrate the bending of metals by shaping them with a hammer. Show examples of metals which have been bent.

- Demonstrate tempering. Use a bobby pin in the experiment. First, show that the bobby pin is elastic. Heat it in the flame of a Bunsen burner and plunge it into cold water. The metal will now break easily. Reheat and allow to cool in air. It will now bend without breaking.

Metals are extracted from ores. Copper is separated by heating the ore with charcoal.

- Heat a small amount of copper oxide and charcoal (1 part of oxide, 3 parts charcoal) in a test tube. Keep the metal red hot for several minutes. Then let it cool. A red copper color forms in the tube.

- Heat cinnabar (mercuric sulfide or mercuric oxide) in a pyrex test tube. Mercury will collect in the upper part of the tube. Caution: Mercury vapors should not be inhaled.

- Discuss how these extracting methods are related to commercial processes.

Alloys are combinations of metals or metals with non-metals.

- Discuss the need for alloys in our world today.

- Show different examples of alloys and discuss their properties.

- Prepare a common alloy, such as iron solder. Weigh equal amounts of tin and lead in a crucible. Cover the surface with 1/2 inch of sodium carbonate and heat. (The sodium carbonate prevents oxidation.) Pour melted solder into a mold and skim off sodium carbonate. For copper solder, use 5 parts tin to 2 parts lead.

- Demonstrate the metals which are used in brass.

  Dissolve a piece of brass in HNO_3. The copper produces a blue-green color. Addition of NH_4OH causes a deeper blue color as copper hydroxide is formed.

  To test for zinc, add 5 cc of concentrated NaOH to the dissolved brass, filter, and add 2 drops of NaS_2 solution. ZnS_2, a white precipitate, will form.

- METALS

Amalgamation is a type of alloying in which mercury alloys with metals. It is an important process in mining, metallurgy, and dentistry.

- Dip a small piece of bronze, which has been scrubbed to remove grease, into an evaporating dish filled with mercury. After a few seconds, the immersed object will be "silvered." Relate to amalgams in extraction of gold. Discuss the harmful practice of "silvering" jewelry with mercury. Caution: Avoid inhaling mercury vapor or permitting it to contact skin.

Many metal objects are plated or coated with other metals.

- Demonstrate electroplating. See page 183 for an experiment on electroplating which may be performed as a class demonstration or as a laboratory experiment for the entire class.

- Show some tin cans and discuss how the steel can rust when the coating is broken or scratched.

- Point out that galvanizing is the coating of iron with zinc. Galvanize a piece of sheet iron. First melt zinc metal in an iron dish. Dip a piece of iron in dilute HCl, and then into the melted zinc. The zinc will coat the iron.

Light affects certain metallic compounds, a reaction which makes photography possible.

- Demonstrate photographic chemicals. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 13, "The Chemistry of Photography." This may be performed as a class demonstration or as a student laboratory activity.

- Prepare a blueprint, which is produced by the reaction of light with iron compounds. Cover blueprint paper with a stencil. Expose to direct sunlight for 2 to 5 minutes. Wash with water. Blueprinting may be included in the above laboratory activity.

The cleaning of metals can be done chemically.

- Show how silver exposed to foods containing sulfur will tarnish. Silver coated with mustard or mayonnaise will tarnish.
- Note that silver may be quickly tarnished by gently heating HCl and a little iron sulfide. Hold a silver spoon over a test tube. Fumes will tarnish silver. Caution: Use hood or be sure that room is well ventilated. Cold water will stop action of dilute HCl.
- Use the electrolytic method to remove tarnish from silver. Use an aluminum pan or aluminum foil in an enamel pan. Use 1 teaspoon each of baking soda and salt to a quart of water. Heat solution to just below boiling point. Leave silver in solution until tarnish is removed. Remove silver and polish with soft cloth.
- Dissolve sodium hyposulfate in a large beaker. Dip a tarnished spoon in the solution. Sodium hyposulfate also reduces silver sulfide tarnish on silver.
- Try the paste method for cleaning silver. Stir 3 tablespoons of powdered neutral soap, 1/2 oz glycerin, 1-1/4 oz water, and 1 teaspoon household ammonia. Stir into mixture of enough powdered whiting to make a firm paste. Store in a covered container. For classroom, use 2 ml green soap, 1 ml glycerine, 3 ml water, and 6 drops household ammonia.

- **TEACHER RESOURCES**

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 20. What Are the Natural Fibers?
Note: Use Chart for Textile Identification by Means of Flame Tests, page 37.

Experiment 13. The Chemistry of Photography

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

Supplementary Laboratory Activities (See Appendix)

Experiment 8.	Commercial Plastics	page 181
Experiment 9.	Electroplating With Copper	page 183

REPORTS

Use of plastics in commercial packaging
Recent developments in plastic paints
Use of impregnated fiberglass
Cloth for boats, and automobile bodies
Production of fiberglass
Tire production
New plastics in the Space Age
Dyes and the dyeing industry
The technical aspects of cleaning fabrics (Interview the proprietor of a dry cleaning establishment)
Federal and state laws concerning textiles and their labeling
Modern methods of weaving fabrics
New fabrics for the Space Age

Amalgams in dentistry
Amalgams in mining
Alloys in the Space Age
The manufacture of iron and steel
The electroplating industry
The extraction of metals from ores
Radioactive metals
Precious metals
The chemistry of photography

PROJECTS

Collect examples of various plastic objects. Classify them as to how they were fabricated, type of plastic, and uses.

Embed small objects in plastic. See References on Plastics, page 48, for directions.

Make a plastic.

Analyze a cross section of a tire.

Collect various samples of natural and synthetic textiles. Identify them.

Dye a number of textiles. Find out which are the best dyes for each fabric. Experiment with some natural dyes, such as beet juice.

Experiment with removing stains from clothing. Stain various pieces of material with coffee, fruit juice, and ink. Show what solvent removes each stain.

Test various samples of cloth for per cent of sizing and thread count.

Collect samples of metals and alloys. Find out the special properties of each kind.

Make various alloys, such as woods metal, solder, electric fuse, bronze, and brass.

Determine the specific gravity of a number of metals.

Investigate the process of welding. Make different kinds of welds to illustrate various methods used.

• TEACHER RESOURCES

AUDIO-VISUAL MATERIALS

Films*

Plastics

Fsd 668.4-5	"The Kingdom of Plastics"
Fsd 668.4-8	"Plastics From Petroleum"
Fsd 660-10	"Pattern for Chemicals"
Fsd 678-1	"The Story of Neophene"
Fsd 666.1-3	"Sand and Flame"
Fsd 681.4-1	"To Greater Vision"
Fsd 678.72-1	"Rubber From Oil"

Textiles

Fsd 677.46-6	"Close-Up of Nylon"
Fsd 677.2-9	"The Disciplined Story"
Fsd 677.47-1	"Facts About Fabrics"
Fsd 677-3	"What Is Cloth?"

Metals

Fsd 621.76-10	"This Is Aluminum"
Fsd 621.71-5	"The Drama of Steel"
Fsd 621.76-1	"Unfinished Rainbows"
Fsd 621.74-8	"The Working of Magnesium"
Fsd 621.76-11	"Pigs and Progress"
Fsd 669.1-12	"Steel Frontiers"
Fsd 672-1	"Pioneers of Progress"
Fsd 669.1-3	"Steel"
Fsd 669.7-9	"Product of the Imagination" (Aluminum)
Fsd 621.9-22	"The Shortest Way" (Die casting)
Fsd 696.1-3	"Moulders of Progress"
Fsd 669.1-4	"The Melting and Refining of Stainless Steel"
Fsd 669.4-1	"Lead from Mine to Metal"
Fsd 693-2	"Aluminum on the Skyline"
Fsd 622.34-2	"Copper Mining"
Fsd 621.701-12	"A Story of Arc Welding"
Fsd 621.72-4	"A Story of Copper"
Fsd 669.1-9	"The Story of Stainless"

---

*Refer to Catalog of Films, Secondary Grades. Los Angeles City Schools. (Publication No. 530, 1962 Edition).

• MODERN MATERIALS

• TEACHER RESOURCES

Filmstrips

S-100	"The Chemistry of Steel" (color)
S-143	"Electroplating"
S-5 (Kit)	"How Steel Is Made" (Filmstrip; 5 bottled samples of raw material with booklet)

FIELD TRIPS

Refer to It's Worth a Visit, Catalog of School Journeys.* Los Angeles City Schools. Publication No. SC-460, 1960 Edition.

Firestone Tire and Rubber Company
2525 Firestone Blvd.
South Gate

B. F. Goodrich Company
5400 E. Olympic Blvd.
Los Angeles

United States Rubber Company
5675 Telegraph Road
Los Angeles

A. J. Bayer Company
2300 E. Slauson Ave.
Huntington Park (A bronze foundry.)

Bethlehem Pacific Coast Steel Corporation
6000 Alcoa Ave.
Vernon (A steel plant.)

Aluminum Company of America
5151 Alcoa Ave.
Vernon (A plant at which aluminum castings are made.)

Request permission from principal to use speakers from industry.
Use authorized speakers secured through industry-education office.

---

*Follow instructions as outlined in the publication for planning school journeys.

• TEACHER RESOURCES

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. *Modern Physical Science*. New York: Holt, Rinehart, and Winston, 1962. pp. 146-171, 71-107.

Pella, Milton O., and Aubrey G. Wood. *Physical Science for Progress*. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 456-475, 269-289.

GENERAL REFERENCES

Joseph, et al. *A Sourcebook for the Physical Sciences*. New York: Harcourt, Brace and World, 1961.

Methods of Using Claro Cast. Fry Plastics Co., Los Angeles.

Embedding Specimens in Transparent Plastic, Turtox leaflet No. 33.

Plastics. J. H. Dubois, American Technical Society.

Cope's Plastic Book. Dwiant Cope, The Goodheart-Wilcox Co.

Denny, Grace G. *Fabrics*. New York: Lippincott, 1953.

Hollan, and Saddler. *Textiles*. New York: Macmillan, 1956.

Bendune, and Pfeiffer. *America's Fabrics*. New York: Macmillan, 1947.

Padgett. *Textile Chemistry and Testing in the Laboratory*. Minneapolis: Burgess

Linton, and Pizzito. *Applied Textiles--Raw Materials to Finished Fabrics*. Albany, N. Y.: Delman Pub.

Feirer, John L. *General Metals*. N. Y.: McGraw-Hill Book Co.

Fraser, and Bedell. *General Metals*. Englewood Cliffs, N. J.: Prentice-Hall

Rusinoff, S. E. *Manufacturing Processes Materials and Production*. Chicago: American Technical Society

Johnson, Carl G. *Metallurgy*. Chicago: American Technical Society

Dull, Metcalfe, and Williams. *Modern Chemistry*. N. Y.: Holt, Rinehart, and Winston, 1958.

• MAN AND MECHANICS

• FORCE AND MOTION

AT FIRST, PRIMITIVE MAN HAD ONLY HIS HANDS TO DO HIS WORK. BUT, AS THE CENTURIES PASSED, HE HARNESSED THE FORCES OF NATURE. HE INVENTED MACHINES TO SAVE TIME AND ENERGY, AND TO PROVIDE HIM WITH TRANSPORTATION AND MANY OTHER BENEFITS.

Concepts and Teaching Suggestions

A force is a push or pull that tends to start, stop, or change the direction of an object to which it is applied. An object is set in motion when a force is applied to it. A force can be measured in terms of grams or pounds.

- Demonstrate some of the forces that affect the position of an object, such as gravity. (Drop an object.) To illustrate centripetal force, twirl an object around your head. In addition, push or pull an object on the demonstration desk.

Various laws of motion have been developed which help to explain why things move as they do.

- Demonstrate Newton's first law, the law of inertia: An object at rest tends to remain at rest. An object in motion tends to remain in motion.

  Place a coin on a card resting on a drinking glass. Snap the card off the glass. The coin should fall into the glass.

  Place a number of pieces of laboratory glassware on a piece of paper on the demonstration desk. Pull the paper out quickly. Caution: Be positive and do not hesitate.

  Demonstrate use of an inertia ball if available.

- Discuss effects of inertia on an automobile and its passengers.

- Discuss inertia in space flight.

- Throw a ball across the classroom. Discuss factors which affect its motion.

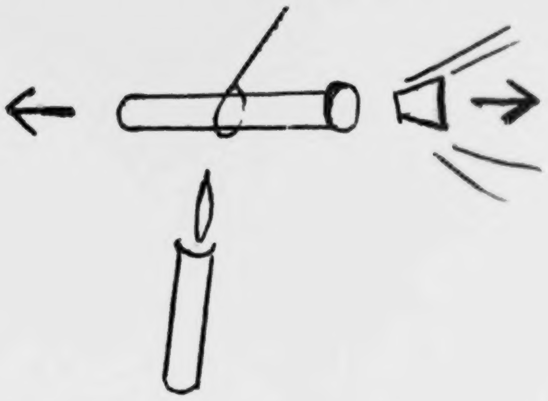
- Demonstrate Newton's second law, the law of momentum or acceleration: the rate at which the momentum (MXV) of a body increases or decreases depends on the amount of force applied to the body.

• FORCE AND MOTION

Discuss the application of the law in terms of moving a small or large object.

- Demonstrate Newton's third law, the law of action and reaction: For every action there is an equal and opposite reaction.

Perform the simple "pop the cork" experiment.



- Discuss relationship of principle to jet and rocket propulsion.
- Relate this law to common tasks, such as pounding a nail or hitting a ball.

Discounting air resistance, all bodies fall with uniform acceleration at 32 feet per second.

- Discuss the falling of two objects, such as a rock or a feather, in the air or in a vacuum.
- Present a simple demonstration by dropping a sheet of paper and a book separately. Place paper directly on book and drop together. Show that the two objects reach the same place at the same time.

Centripetal force is the force that must be exerted on a moving body to make it move in a circular path.

- Twirl a rock or other object on the end of a string.
- Ask a student to twirl a half-filled water bucket to illustrate that water will not spill at top of the arc.

- Discuss application of principle in washer, dryer, or mixer.
- Discuss law in terms of satellite orbits.
- Discuss application in terms of proposed space stations.

The gyroscope works on the principle that a spinning object tends to keep its axis unchanged.

- Demonstrate with a toy gyroscope or a Foucault type, which appears on the Modern Science Equipment List.
- Demonstrate a gyroscope bicycle wheel. Borrow from the physics stockroom.
- Discuss use of the gyroscope in navigation and as a chief instrument of space navigation in the actual guidance of rockets.

Elasticity is a property that enables an object to return to its original shape when a force is applied to it unless its elastic limit has been exceeded.

- Demonstrate the application of this principle with a rubber band or with Hooke's law apparatus.
- Relate the application of this principle to kitchen and bathroom scales and other spring balances.

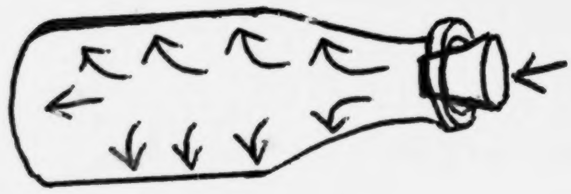
• FLUIDS

FLUIDS INCLUDE BOTH LIQUIDS AND GASES. CERTAIN PRINCIPLES INVOLVING PRESSURES OF THESE MATERIALS HAVE MADE THEM IMPORTANT IN MANY LABOR-SAVING DEVICES. LIQUIDS EXERT PRESSURE. THIS MAY BE DUE TO THE EFFECTS OF GRAVITY (GRAVITY PRESSURE) OR TO PRESSURE APPLIED TO THE LIQUID FROM WITHOUT.

Concepts and Teaching Suggestions

The pressure of a confined liquid is the basis for Pascal's law: Pressure in a confined fluid acts equally in all directions at any given depth. Hydraulic machines work on this principle. Man's strength can be multiplied tremendously through its application.

- Demonstrate with a corked milk bottle the principle of hydraulic pressure. Caution: Do not press hard on the cork.



- Use a squirt gun to demonstrate the hydraulic concept. Show a diagram of a hydraulic press.
- Demonstrate a portable hydraulic jack or press as an example of the use of hydraulics.
- Discuss the hydraulic lift at service stations as an example of hydraulics.
- Discuss automobile hydraulic brakes as another example.

Pressure in liquids depends on the depth that an object is beneath the surface and on the liquid's density, which is called gravity pressure.

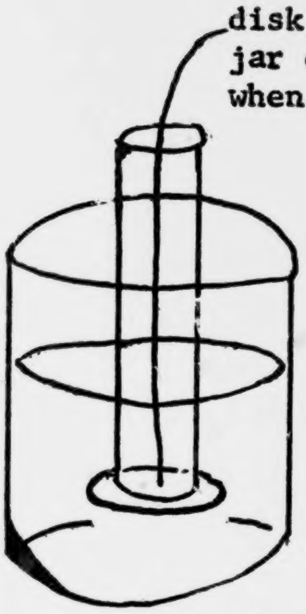
- Demonstrate the principle with a can in which holes have been punched in the side. Fill with water. Notice the force with which the water spurts from the can at various levels.
- Discuss the application of this principle in the building of dams.

Size and shape of the container have no effect on the gravity pressure.

- Demonstrate with Pascal's vases and equilibrium tubes.

In any given depth liquids, exert the same pressure in all directions.

- To demonstrate the principle, fasten a cord with sealing wax to a disk large enough to cover the end of a glass tube. Immerse in a jar of water. Pour water into cylinder until disk falls. Observe when this occurs. Discuss principle involved.



Water tends to rise to the height of its source because of the pressure that the water exerts.

- Demonstrate principle with a steam boiler or tea kettle.

Gravity pressure is applied to distribute water in water systems.

- Discuss the use of water towers and water systems.
- Demonstrate with can and tubing how pressure increases as can is lifted.
- Discuss use of principle in developing power at dams.

Fluids push up objects immersed in them and make them seem to lose weight. This is the principle of buoyancy.

- Demonstrate that the loss in weight is equal to the water displaced. Weigh an object in air and then in water, using an overflow can. Weigh the quantity of water that overflowed. Show that its weight is equal to the apparent loss of weight of the original object. See Dull, Metcalfe, Williams, Physics Workbook, Experiment 22, "Archimedes' Principle."

• FLUIDS

An object will float if it weighs less than an equal volume of liquid.

- Demonstrate application of principle by placing cork and piece of metal in water.
- Discuss how ships and balloons depend on buoyant force to float.
- Float an iron ball in a dish of mercury. Discuss the principle involved.

Specific gravity is found by comparing the weight of a substance with the weight of an equal volume of water (weight of an object divided by the weight of an equal volume of water).

- Discuss the value of knowing the specific gravity of a substance.
- Demonstrate specific gravity. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 28, "Finding Specific Gravity By Buoyancy." This demonstration may be performed as a laboratory activity for the entire class.
- Demonstrate the use of the hydrometer in finding the specific gravity of liquids. Immerse hydrometers in cylinders filled with alcohol, water, salt water, or other liquids. Discuss why the hydrometer sinks or floats higher in the various liquids.
- Point out uses of the hydrometer in industry (gasoline, sugar, soap, milk).
- Show battery hydrometer and explain use.
- Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 29, "Are Some Liquids Denser Than Others?"

• MAN AND MECHANICS

• AIR PRESSURE

AN UNDERSTANDING OF AIR PRESSURE IS AN IMPORTANT PART OF UNDERSTANDING MAN'S MECHANICAL WORLD.

Concepts and Teaching Suggestions

Air exerts pressure.

- Show how blowing into a balloon causes it to expand.
- Discuss the use of air pressure in balloons, tires, and other inflated objects.
- Fill a water glass with water to overflowing. Cover with cardboard. Place hand on cardboard and invert the water glass. Remove hand from cardboard.
- Demonstrate emptying a can without a vacuum pump. Almost fill a gallon can with water. Attach a stopper and a 25-foot length of rubber hose. Drop hose out the window. As the water leaves the can because of gravity, air cannot replace it. Therefore, the can will collapse because of air pressure.
- Perform the "crushed can" experiment. Use an old gallon can. Drive out some of the air by heating. Replace top and allow to cool. Can will collapse.
- Remove shell from a boiled egg. Place egg on the opening of a milk bottle after dropping a piece of burning paper into the bottle.
- Try to pour water from a bottle in which a glass tube has been inserted.
- Demonstrate effects of air pressure using Magdeburg hemispheres.

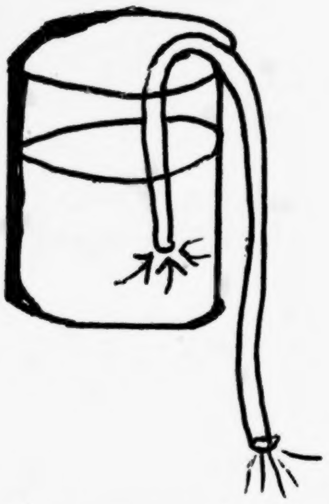
Air pressure can be measured by using a barometer or other gauges.

- Construct a Torricelli barometer. Show that the height of the column of mercury varies with the air pressure. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 30, "How Does a Mercury Barometer Work?"
- Show various devices to measure air pressure, such as a tire gauge, air compressor gauge, altimeter, and aneroid barometer.

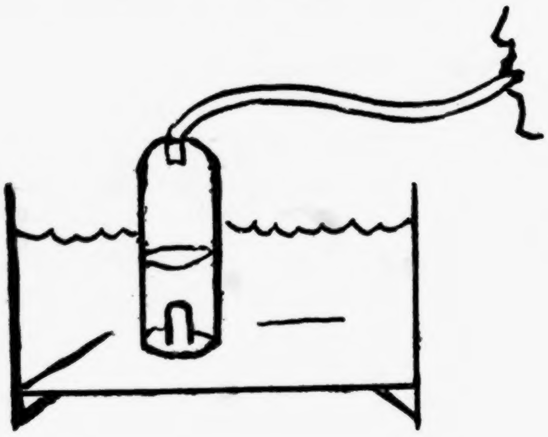
• AIR PRESSURE

Various devices useful to man depend on air pressure to work.

- Show various devices that work on the basis of air pressure, such as medicine droppers, atomizers, aerosol cans, suction cups, and fountain pens.
- Demonstrate the pressure principles involved in the use of the vacuum cleaner. Bring vacuum cleaner from home.
- Demonstrate use of pressure cooker. Discuss the reasons for the difficulty of cooking at high altitudes.
- Demonstrate use of force pump and lift pump.
- Make a siphon and show how it works. Use rubber tubing and a battery jar.



- Discuss use of compressed air in tires, caissons, pneumatic drills, and sandblasting.
- Make a caisson and demonstrate its use.



• MAN AND MECHANICS

• MACHINES

MACHINES OF MANY VARIETIES ARE LABOR-SAVING DEVICES FOR MAN.

Concepts and Teaching Suggestions

A machine is any device that changes the amount, speed, or direction of a force.

- Show simple tools or implements used in the home or workshop. Determine whether each changes the amount, speed, or direction of a force and helps man to perform work more easily or better.

All machines are made up of a few simple machines.

- Examine with the class several tools or household implements which are basically simple machines. Determine what kind of simple machine each one is.
- Demonstrate the simple machines used in a bicycle.
- Demonstrate the 3 classes of levers. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 25, "How Do You Use Levers to Do Work?"

1st class	2nd class	3rd class
scissors	nutcracker	shovel
teetertotter	wheelbarrow	tweezer
hammer	bottle opener	hoe
crowbar		sugar tongs
		paint brush

A compound machine consists of an arrangement of two or more complicated machines.

- Examine and operate an egg-beater, typewriter, or other compound machine used in the home or shop, and determine the kind of simple machines of which each is composed.

Work is the product of force X distance. (f X d)

- Ask a student to lift an object from the floor to a table. Determine the amount of work done.
- Compare work done in raising objects of various weights for different distances.
- Discuss the foot-pound.

- MACHINES

The rate of doing work is measured in units known as horsepower. One horsepower is equal to 550 ft-lbs of work done in one second.

- Compute the horsepower developed when a student runs up a flight of stairs. Caution: Students who are excused from physical education for medical reasons should not do this exercise.
- Use a stop watch to determine the amount of horsepower developed by a student when he turns the handle of a meat grinder.
- Examine several electric motors and note horsepower ratings.

Mechanical advantage indicates how much work is put into a machine as compared to its output.

- Demonstrate the mechanical advantage of an inclined plane. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 26, "Inclined Planes Are Simple Machines." This experiment may also be performed by the entire class.
- Discuss or demonstrate the mechanical advantage of a lever and pulley.

All machines waste some energy.

- Measure the amount of work put into a block-and-tackle system, and compare this with the amount of work obtained from it. Discuss the reason for any difference.
- Determine the amount of force needed to move a book or wooden block across the top of the desk. Support the book or block by several round pencils and determine the amount of force needed. Compare and explain.
- Make a model of a ball-bearing by placing a ring of marbles around a metal can lid. Set a smaller lid in the center. Lay a piece of cardboard on the bearing and turn it over on the desk top. Rotate a heavy object on the desk top. Place object on bearing and rotate. Compare the amounts of energy expended.
- Exhibit samples of ball bearings and roller bearings. Dismantle simple machines and note bearings.
- Discuss the need for bearings and for proper lubrication of machines.
- Discuss and demonstrate proper lubrication of common shop and household equipment.

• MAN AND MECHANICS

• POWER TRANSMISSION (Optional)

MECHANICAL POWER MAY BE TRANSMITTED BY PULLEYS, BELTS, AND GEARS.

Concepts and Teaching Suggestions

Pulleys and belts transmit power developed by an engine or an electric motor.

- Exhibit and operate power tools or home appliances in which pulleys and belts are used to transmit power.
- Study the relationship between sizes of pulleys and speed of motors. Note the effect of crossing belts.
- Study several machines using pulleys and belts as a means of power transmission and determine their advantages and disadvantages.

The gear is a common device for power transmission.

- Examine a hand mixer or hand drill. Note use of gears to transmit mechanical power. Ask students to suggest other uses of gears to change speed and direction of motion.
- Use an erector set to demonstrate the worm gear, which transmits power through right angles.
- Show the gear trains in a fishing reel and in an electric mixer.
- Show workings of a clock. Note use of gears to transmit power.
- Present a demonstration of a gear train. Slowly rotate gears and note direction and speed of rotation. Count number of teeth in each gear and correlate with change in speed. Correlate number of gears with change in direction of motion. Use three-geared brass wheel.

Power may be delivered directly from a motor.

- Examine polishing and grinding machines or electric fan as examples.

• ENGINES AND MOTORS

ENGINES AND MOTORS ARE LABOR-SAVING DEVICES WHICH CONVERT FORMS OF ENERGY INTO MECHANICAL ACTION WHICH CAN BE MADE USEFUL.

Concepts and Teaching Suggestions

The steam turbine is turned by the velocity or expansion of steam.

- Demonstrate model water wheels and their use in hydroelectric plants.
- Demonstrate a home-made model of a steam turbine.
- Discuss applications of the steam turbine. Show charts, diagrams, or pictures of such applications.

In the steam engine, a boiler generates steam which, under pressure, pushes a piston. Steam is admitted to alternate sides of the piston by a slide valve, which makes the piston slide back and forth. This action is converted to a rotary motion.

- Use steam to pop a cork from a brass tube by boiling a small quantity of water in the bottom of the tube.
- Note the operation of a toy steam engine and the purposes of its major parts.
- Demonstrate a cut-away model of a steam engine.
- Discuss the uses of the steam engine.

The gasoline engine is an internal combustion engine which converts the energy of fuels into the energy of motion. The four strokes of the engine are intake, compression, ignition, and exhaust.

- Show cut-away model of a gas engine.
- Demonstrate plastic model of automobile engine, showing working parts.

In the Diesel engine, a high temperature produced by high compression of air, is used for ignition.

- Demonstrate heat of compression by working an air pump against back pressure.

- Compare gasoline and Diesel engine strokes.
- Discuss advantages and uses of the Diesel engine. Use a gas model airplane engine to demonstrate the Diesel effect.

The electric motor converts electrical energy into mechanical energy.

- Demonstrate the operation of a small electric motor.
- List common household and shop appliances in which electric motors are used.
- Exhibit common household and shop implements containing electric motors. Discuss care of the motors.
- Describe the action of the St. Louis motor. Ask students to connect it to a switch.
- Show various types of commercial motors. Discuss their uses.

Nuclear reactors are operated by the heat of atomic energy, which boils water to make steam. The steam operates a turbine, which drives an electric generator to produce electric power.

- Discuss use of nuclear reactors.
- Exhibit charts illustrating production of nuclear energy.
- Present and discuss a flow chart illustrating the production of electricity by atomic energy.

The jet engine works on the action-reaction principle, Newton's third law.

- Show diagrams of the jet engine and of the turbo jet, ram jet, and turbo prop.
- Discuss the action-reaction principle involved.

The rocket engine is like a jet engine, but it does not need an air supply, because the fuel contains the source of energy.

- Show model diagram of rocket motor.
- Discuss the use of rockets for space travel.

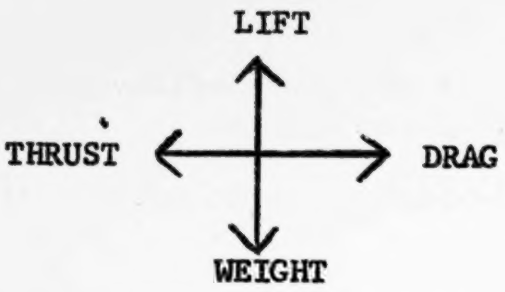
- FLIGHT

FLIGHT OF HEAVIER-THAN-AIR CRAFT IS THE RESULT OF MAN'S CONTROL OF FORCES.

Concepts and Teaching Suggestions

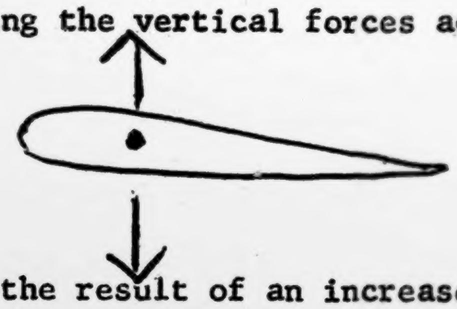
An understanding of flight is based on an understanding of the vertical and horizontal forces acting on a plane.

- Draw a diagram showing all of the vertical and horizontal forces acting on a plane.



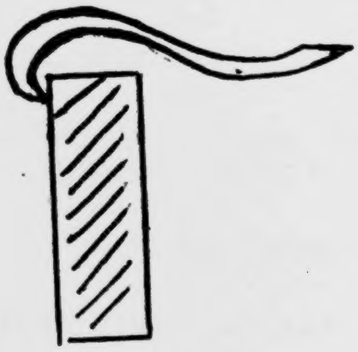
A plane is influenced by vertical forces. The earth's gravitational attraction for the airplane gives it weight and a downward force.

- Draw a diagram showing the vertical forces acting on an airplane.



The lift of an airplane is the result of an increase in pressure on the underside of the wing and a decrease in pressure on the top of the wing. This is called Bernoulli's principle.

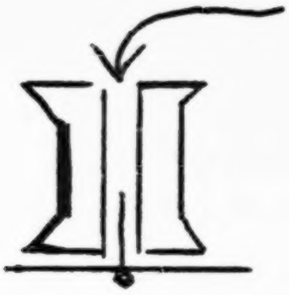
- Demonstrate the movement of air from a fan or vacuum cleaner. Use a vacuum cleaner exhaust tube as an air source.



• MAN AND MECHANICS

• FLIGHT

- As examples of the application of Bernoulli's principle, suspend a ping-pong ball in a jet of water and then in a jet of air.
- Blow between two balloons hanging together.
- Try to blow the card away from the spool, as arranged in the diagram below.



- Explain why a spinning ball curves and how a spray gun works.

Lift varies in relation to the angle of attack. Low-speed aircraft receive more lift from reduced pressure on the top of the wing, while higher-speed aircraft with wings that have razor-sharp leading edges receive more lift from increased pressure on the underside of the wing.

- Hang a model airplane from a balance and weigh it. Measure its increase or decrease in weight when a fan is directed toward the plane. Try several times, using various angles of attack.

A plane is influenced by horizontal forces. Drag is the resistance of the air moving around the airplane. This varies with the shape of the airplane, the density of the air, the airplane's surfaces, and the angle of attack.

- To demonstrate three varying degrees of drag, simultaneously drop three 20-g weights--one with a small cloth parachute attached, one with a paper streamer attached, and one without any attachment. Discuss the value of drag, and ways of using it for braking.
- Discuss the friction of air affecting a surface as a part of drag.
- Use a spring balance attached to a block of wood to show that there is a force of friction that must be overcome before motion can be produced.
- Discuss what is meant by flight altitude. Show the effects of streamlining and eddy current by moving a tongue depressor stick edgewise and flatwise through water. Measure the drag of a model airplane handing from a spring balance in the downward moving air stream of a fan.

- FLIGHT

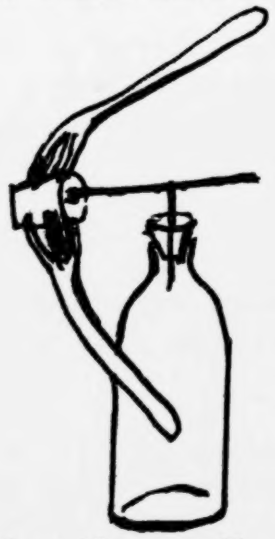
Thrust provided by a power plant must first overcome drag and inertia before it can produce forward motion. (The type of power plant to be used is determined by the altitude of flight, speed to be attained, length of air strip, fuels available, and economic factors.)

- Mount a propeller on a lightly greased wire and spin. Notice the direction of the thrust. Change direction of rotation of propeller.
- Measure thrust, using a propeller driven by a twisted rubber band. Note how the thrust varies with the speed of the propeller.
- Measure the thrust of an electric fan at various speeds. Caution: Use rubber blades or a metal guard.
- Ask students to measure the magnitude and direction of two forces and their resultant by using three spring balances. Scaled drawings could be made of these to check results.

  Scale drawings (vectors) can be used to work out problems.

The ailerons, elevators, and rudder help the plane to turn about its center of gravity. The center of gravity changes as the plane's load of fuel and passengers is changed.

- Demonstrate center of gravity by spinning a piece of irregularly shaped cardboard into the air and noting that it spins about a single point.
- To illustrate center of gravity and stability, perform some balance demonstrations, such as balancing an inverted pie tin on a needle or a weighted meter stick on a knife edge; or weighting a ball on one side.



The forks, cork, and pin will balance and can be made to spin on the pin's side, which rests on the needle point.

The center of gravity is below the needle point.

- Discuss the action of a bomber when it releases as much as one-half of its weight in flight.
- Ask a student to demonstrate flying a model airplane.
- Discuss the effect of the center of gravity on fuel consumption.
- Discuss the tendency for the main body of a helicopter to rotate in the opposite direction from the motor blades. Apply also to an airplane, in which the solution may be to rotate two propellers in opposite directions or use trim tabs.

One of the problems of flight is centrifugal force. This is the outward pull of a revolving body away from the center of revolution.

- Demonstrate a centrifuge.
- Discuss the action of the spin dryer in a clothes washer, and its action when it is unbalanced.
- Discuss the safest place to sit in an airliner in case the prop were to fly apart or to break loose.
- Discuss the increase in the pilot's body weight on high-speed turns.
- Discuss the effects on the blood in the circulatory system during tight turns.
- Discuss the principle of centrifugal force to an automobile as it goes around a corner. Relate to static friction first and then to sliding (kinetic) friction as skidding begins. Point out how to pull out of such a skid by increasing the radius of curvature.

At high speeds, an aircraft will travel great distances during the three-fourths of a second required for a man's perception and reaction time.

- Discuss "collision course," in which the pilot perceives that he will collide, but knows that his controls will not react quickly enough to change his direction of flight sufficiently to avoid a collision.
- Relate to mid-air collisions.
- Ask a student to learn what is the latest speed record for aircraft, using the Reader's Guide in the library as a reference. Ask class members to compute how far a pilot will travel in three-fourths of a second.

- FLIGHT

  - Discuss automatic controls, such as the automatic pilot; automatic electronic control systems to avert mid-air collisions; and automatic control systems in interceptors that take over from the pilot, control the plane until rockets are launched, and then take over direction of the rocket.

Pressurized cabins require stronger aircraft and greater safety precautions.

- Discuss pressurization of aircraft.

Subsonic to supersonic speeds require strong construction because of vibration at the sonic speed and also have required development of new metals that can withstand the high temperatures.

- Discuss Mach number. Practice converting to and from Mach numbers at various altitudes.
- Compare an automobile's rise in temperature of .6 degrees F. at 60 mph to a missile's rise in temperature of 1,600 degrees F. at 3,000 mph.
- Heat 1/4" strips of several different metals, such as aluminum, copper, stainless steel, at the apex of the Bunsen burner cone. Note the difference in bending with tongs. Caution: Place asbestos mat under working area.
- Recall work done on alloys.
- Discuss sonic booms.

A pilot must learn to use a number of instruments to help him navigate his aircraft.

- Show pictures of an instrument panel of an aircraft and indicate what some of the instruments are.

Many new types of planes are now in the air as a result of the development of the flight instruments and engines.

- Discuss some new types of aircraft, such as the helicopter, the jetplane X-15, and the vertical take-off plane.

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 28. Finding Specific Gravity by Buoyancy
" 29. Are Some Liquids Denser Than Others?
" 25. How Do You Use Levers to Do Work?
" 26. Inclined Planes Are Simple Machines
" 27. Forces Pulling at an Angle
" 30. How Does a Mercury Barometer Work?

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

REPORTS

"Perpetual motion" machines
Atomic energy as a source of power
Automation and society
Nuclear submarines
Block and tackles in action
Construction and action of jet engines
Work of Archimedes
Operation of caissons
Submarines
Deep-sea diving and pressure
Skin diving and pressure
Safety-belts
Helicopters
VTOL (Vertical take-off and landing planes)
Sonic boom
Instruments used in flight

• TEACHER RESOURCES

PROJECTS

Build a plastic model of an engine. Construct a steam turbine.

Construct a simple electric motor.

Make a compound machine by putting together several simple machines from the laboratory or from an erector set.

Using parts of an automobile, demonstrate the application of simple machines.

Build a small car or model plane apparatus with a carbon dioxide cartridge.

Make and calibrate a home-made hydrometer.

Collect a number of materials and test their specific gravities. Organize the results of the tests on a chart.

Collect articles or pictures illustrating everyday uses of fluid pressure.

Collect and classify some simple machines.

Build a model wind tunnel and show its action on a model airplane.

Build and learn to fly a model airplane with a gas engine.

AUDIO-VISUAL MATERIALS

Films

Fsd 621-1	"Simple Machines"
Fsd 531.8-2	"Force and Motion"
Fsd 530.1-1	"Galileo's Laws of Falling Bodies"
Fsd 531.5-1	"Gravity"
Fsd 621.436-8	"The Diesel Story"
Fsd 532-3	"Harnessing Liquids"
Fsd 629.25-1	"ABC of Internal Combustion Engines"
Fsd 621.4-2	"ABC of Jet Propulsion"
Fsd 621.436-9	"ABC of the Diesel Engine"
Fsd 621.43-6	"The Gas Turbine"
Fsd 658.56-1	"This Is Automation"
Fsd 629.13-9	"Romance of the Gyroscope"
Fsd 629.13-28	"Report on Jet Propulsion"
Fsd 629.14-1	"Jet Propulsion"
Fsd 629.13-38	"An Introduction to Jet Engines"
Fsd 921 New-1	"Isaac Newton"
Fsd 531-5	"Laws of Motion"
Fsd 531.8-1	"Lever-Age"
Fsd 629.133-2	"Heart of the Missile"
Fsd 629.13-15	"Drag"
Fsd 629.13-35	"Jet Wings for Tomorrow"
Fsd 629.13-11	"Science of Flight"

Filmstrips

S-85	"Diesel Engines"
S-80	"Energy and Engines"
S-84	"Gasoline Engines"
S-86	"Jet Engines and Rockets"
S-83	"Steam Engines"
S-81	"Wind and Water Engines"
S-106	"The Wonder World of Science--Moving Things"
S-37	"Jets and Atomic Power"
S-75	"The Pulley Makes Work Easier"
S-31	"Simple Machines" (2 sets)
S-26	"Centrifugal Force"
S-87	"Elementary Science Series" (2 sets)
S-57	"Energy Unlimited--Energy, Work, Horsepower"

• TEACHER RESOURCES

FIELD TRIPS

Refer to It's Worth a Visit, Catalog of School Journeys. Los Angeles City Schools. Publication No. SC-460, 1960 Edition.

Chrysler Corp.
5800 Eastern Ave., Los Angeles

Los Angeles International Airport
5800 Avion Dr., Los Angeles

Ford Motor Co.
8900 E. Washington Blvd., Pico Rivera

General Motors Corp.
2700 Tweedy Blvd., South Gate

Long Beach Naval Shipyard (cranes at work) Long Beach

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 219-275, 280-307.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 291-331.

GENERAL REFERENCES

Dull, Metcalfe, and Williams. Physics Workbook. New York: Holt, 1960.

Joseph, et al. A Sourcebook for the Physical Sciences. New York: Harcourt, Brace and World, 1961.

Brooks, Tracy, and Tropp. Teacher's Manual and Answer Book, Modern Physical Science. New York: Holt, Rinehart and Winston, 1962.

Tower, M. E. Basic Aeronautics. Aero-publishers, 1952.

• HEAT AND FUELS

• NATURE OF HEAT

HEAT IS A FORM OF ENERGY NECESSARY FOR HUMAN SURVIVAL. THROUGH PROPER CONTROL, HEAT CAN BE CONVERTED INTO USEFUL WORK.

Concepts and Teaching Suggestions

Heat is a form of energy possessed by a substance because of the motion of its molecules.

- Demonstrate the motion of molecules by showing the changes of state of water from ice to water to steam.
- Describe the increase in molecular motion and the subsequent increase in the heat of water as it changes state. Also describe how ice forms when water cools sufficiently to reduce the speed of water molecules.

Heat may be obtained or released from chemical action, electrical energy, friction from motion, and nuclear changes.

- Demonstrate various simple ways of producing heat. Illustrate chemical action by lighting a match or by some other burning action; electric energy by lighting a light globe or electrical appliance, such as a toaster; and friction by rubbing the hands together.
- Discuss nuclear reactions as a source of heat and the fact that the sun's heat comes from nuclear reactions.
- Discuss evidence that the earth's interior is hot.

Temperature, or the degree of hotness of a material, is measured with a thermometer. Thermometers work on the principle that a material expands when heated and contracts when cooled.

- Demonstrate an air thermometer or water thermometer. See Brooks, Tracy, and Tropp, Modern Physical Science, 1962 Edition, page 179, for description of procedure.
- Show a mercury thermometer and discuss the expansion and contraction of the mercury.
- Discuss how a metal thermometer works by contraction and expansion of a coil of wire.

• NATURE OF HEAT

Temperatures reaching 3000°F need pyrometers as measuring instruments.

- Demonstrate a thermocouple combined with a millivoltmeter. (When heated, the thermocouple will produce a measurable electric current.)
- Explain the operation of an optical pyrometer.
- Heat a piece of polished steel in a Bunsen flame to show color changes.
- Discuss the necessity of using pyrometers in steel mills and foundries.
- Obtain ceramic pyrometers from the ceramic instructor. (See Olivo, and Wayne, Basic Science, page 248, for information on pyrometers.)

There are two common scales for measuring temperature--the Fahrenheit scale and the Centigrade (Celsius) scale.

- Demonstrate the two temperature scales and show how they differ.
- Show the formula for the conversion of Centigrade to Fahrenheit.

$$C = (F - 32)\,\frac{5}{9};\ \text{or},\ F = \left(\frac{9}{5}C\right) + 32$$

- Demonstrate that 0°C on the Centigrade thermometer is the melting point of ice.
- Demonstrate that 100°C is the temperature at which water boils.
- Refer to absolute zero and the Kelvin scale.

Calories are used to measure the quantity of heat expended. One calorie is the amount of heat required to raise the temperature of 1 gram of water 1 Centigrade degree. The amount of heat required to raise 1,000 grams of water 1 Centigrade degree is a large calorie.

- Display a calorimeter (a device to determine heat loss or gain). See Dull, Metcalfe, and Williams, Laboratory Experiments in Physics, Experiment 35, "Law of Heat Exchange," for additional information.

• HEAT AND FUELS

• NATURE OF HEAT

The B.T.U. is the amount of heat required to raise the temperature of 1 pound of water 1 Fahrenheit degree.

- Discuss this measurement of heat in terms of buying a heating appliance.

Specific heat is the amount of heat that a material can hold. This measurement has important applications. For example, aluminum utensils hold twice as much heat as steel utensils of equal weight.

- Compare the specific heats of different metals. Prepare cylinders of the same size (about 1" long), containing such metals as copper, brass, steel, and iron. Bring cylinders to the temperature of boiling water and transfer to a vertical inclined plane made from a piece of wood and a piece of beeswax cell. Hold away from the board by corks. The cylinders will slide down the incline, melting a track through the wax. The length of the track will depend on the specific heat of the metal.

Heat causes materials to expand, the amount of expansion depending on the material.

- Demonstrate linear expansion apparatus.

- Demonstrate a ball and ring apparatus.

- Discuss some common applications of the principle of expansion, such as in opening a bottle and riveting.

The rate (or coefficient) of linear expansion of metals is important in building and other activities typical of modern civilization.

- Relate to the expansion and contraction of bridges. Why are gratings placed at the ends of bridges?

- Show the bimetal bar.

- Explain the reason for the clicking sound which occurs when a train travels on railroad tracks.

Thermostats are temperature regulators.

- Show a model of a thermostat. Demonstrate its action in ringing a bell or other device.

- **NATURE OF HEAT**

A solid becomes a liquid when a quantity of heat is absorbed to change its state. (When ice melts, each gram absorbs 80 calories.) This is called the heat of fusion.

- Demonstrate the laboratory activity associated with this concept. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 21, "It Takes Heat to Melt Ice."
- Discuss how ice in a refrigerator reduces the temperature of foods.

It takes more heat to change the state of a liquid from its boiling point to a gas than it does to bring the water to a boil. (Boiling water absorbs 540 calories when it becomes a vapor.) This is called the heat of vaporization.

- Demonstrate the laboratory activity associated with this concept. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 22, "Steam Has Stored Heat."
- Discuss the cooling effects of evaporation.
- Show a diagram of the mechanism of a refrigerator and describe how ice is formed as a result of the absorption of heat.

Boiling occurs when the vapor pressure of the liquid increase by heat is equal to the pressure on the surface of the liquid.

- Demonstrate by bringing cool water to a boil. Half fill a round-bottomed flask with water. Bring the water to the boiling point over a flame. Stopper the flask tightly and invert over the sink. Pour cold water over the flask. Water will boil again. (Cooling condenses the water vapor and reduces the pressure on the water so that it will boil at a lower temperature.)

HEAT IS TRANSFERRED IN THREE WAYS--BY CONDUCTION, CONVECTION, AND RADIATION.

Concepts and Teaching Suggestions

Conduction is the progressive transfer of the motion of molecules through a material. Most metals are good conductors. Most liquids, gases, and non-metallic solids are poor conductors and therefore are insulators.

- Demonstrate conduction. With melted paraffin, attach thumb tacks at intervals along a copper bar (30 cm). Heat one end of the bar. Show that heat moves along by conduction as thumb tacks drop off.
- Show application of the principle of Davy Miner's lamp. Hold a metal screen in a gas flame. Observe that the flame does not come through the screen because it conducts the heat away.
- Hold a piece of paper over a flame until it chars. Place a metal coin on the paper and repeat. The metal will conduct the heat away from the paper, thus preventing the paper from burning.
- Display a number of materials used as insulators.
- Discuss the use of dead air space.

Convection is the transfer of heat by circulation of portions of fluids, liquids, or gases.

- Demonstrate by using convection apparatus for gases.
- Demonstrate the action of convection liquids. See Brooks, Tracy, and Tropp, Modern Physical Science, 1962 Edition, page 187.
- Discuss practical application of convection currents in heating a room. Explain afternoon sea breezes.

- **HEAT TRANSFER**

Radiation is the transfer of heat by waves through space. Transfer may occur through a vacuum.

- Discuss the fact that heat from the sun comes to the earth by radiation.
- Demonstrate that heat radiates from a lighted globe or from a radio tube.
- Demonstrate the radiometer.
- Discuss the vacuum bottle.

Heat rays may reflect, penetrate, or be absorbed.

- Demonstrate that light surfaces reflect heat and that dark surfaces absorb heat. Use three tin cans. Paint one black and one white. Leave the third one shiny. Fill the cans with very cold water and place them in a warm place or in the sun. Ask a student to record the temperature at 5-minute intervals and to report the results to the class.

• HEAT AND FUELS

• FUELS

A FUEL IS ANY MATTER USED TO PRODUCE HEAT OR POWER BY COMBUSTION. THE THREE MOST COMMON TYPES ARE COAL, PETROLEUM, AND NATURAL GAS.

Concepts and Teaching Suggestions

Coal is a fossil fuel.

- Discuss the importance of fuels for heating, for transportation, and for industrial processes.
- Discuss the stages in the formation of coal. Show samples of peat, lignite, bituminous, and anthracite coal.
- Demonstrate the destructive distillation of coal and wood. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 23, "How to Make Charcoal and Coke,"
- Discuss the by-products which result from the above process.

Natural gas is a common household fuel in many communities.

- Point out the convenience of the fuel readily available on the laboratory desk.
- Discuss some of the properties of natural gas, such as the fact that it is odorless. Odor is added to make it perceptible to humans.
- Discuss the dangers of unvented gas heaters.

Petroleum, an oily liquid found underground, is also an important modern energy source.

- Show films or filmstrips of prospecting, drilling, and refining petroleum.
- Display petroleum samples. See Kit S-12, listed in the Catalog of Audio-Visual Materials, 1962 Edition.
- Demonstrate by teacher only, fractional distillation. See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 24, "Gasoline Is A Mixture of Several Compounds."

  Caution: Use a sand bath under the distilling flask. An electric cone heater is more safe than a Bunsen burner. A small quantity of gasoline will not create a real hazard.
- Show a chart or a fractionating tower. Discuss the various by-products.

- **TEACHER RESOURCES**

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 21. It Takes Heat to Melt Ice (heat of fusion)
" 22. Steam Has Stored Heat (heat of vaporization)
These experiments are excellent in teaching students how to gather accurate data. Calculations (in most cases) should be worked out by the class with the teacher, using data supplied by each experimenting team.
Experiment 23. How to Make Charcoal and Coke
This is a good teacher demonstration.
Experiment 24. Gasoline Is a Mixture of Several Compounds

REPORTS

Radiant heating in drying and baking
Cryogenics, the study of the behavior of materials at low temperatures
Production of dry ice and liquid air
Insulation of homes
Modern home heating devices
Hydronics, electric radiant heating, and electric radiant glass heating
Air conditioning
Refrigeration
Cooking at high altitudes
The use of pyrometers in industry

PROJECTS

Collect and display samples of various insulating materials used in home and industry.

Obtain old thermostats from an automobile, a heater, and other equipment. Describe how they are used.

• HEAT AND FUELS

• TEACHER RESOURCES

AUDIO-VISUAL MATERIALS

Films

Fsd 541.36-1	"Combustion"
Fsd 614.84-17	"Fire Prevention"
Fsd 622.331-18	"Prospecting for Petroleum"
Fsd 625.5-4	"Refining Oil for Energy"
Fsd 523.7-2	"Our Mr. Sun"
Fsd 668.52	"Story of Gasoline"
Fsd 921 No-1	"Story of Alfred Nobel"

Filmstrips

S-35	"Matter and Energy--Man's Use of Power"
S-58	"Air Age Physics" Part 1 Putting Heat to Work Internal Combustion Engine Gas Expansion, Heat Expansion, Heat Transfer Part 2 Measurement of Heat, Temperature, Humidity, Refrigeration, Vaporization, Fusion
S-87	Elementary Science Series IV. "How Heat Is Transferred"
S-147	"Heat and How It Is Measured"
S-103	"Pictorial Physics--Heating Your Home"
S-28	"Energy--Today and Tomorrow"
S-68	"Drilling for Oil"
S-88	"Oil: From Earth to You"
S-13	"The Story of Oil"

Exhibits

S-12	"Petroleum," Set 1 (18 sample bottles, 6 jars, 2 books, 4 folded charts, 1 key chart)

- **TEACHER RESOURCES**

FIELD TRIPS

Refer to It's Worth a Visit, Catalog of School Journeys. Los Angeles City Schools. Publication No. SC-460, 1960 Edition.

Shell Oil Co.
20945 S. Wilmington Ave., Wilmington

Union Oil Refinery
1660 W. Anaheim St., Wilmington

Southern California Gas Co.
810 S. Flower St., Los Angeles

Follow instructions as outlined in the publication for planning school journeys.

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 173-215.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959.

GENERAL REFERENCES

Dull, Metcalfe, and Williams. Modern Physics. New York: Holt, and Rinehart. pp. 217-267.

Dull, Metcalfe, and Williams. Laboratory Experiments in Physics. New York: Holt, 1960.

Olivo, C. Thomas, and Alan Wayne. Basic Science. Albany, New York: Delmar, 1957. pp. 246-289.

Joseph, et al. A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. pp. 392-425.

• NUCLEAR ENERGY

• STRUCTURE OF MATTER

THE DEVELOPMENT OF NUCLEAR ENERGY AS A SOURCE OF POWER FOR MANKIND HAS RESULTED FROM THE STUDY OF THE INTERNAL PART OF THE ATOM.

Concepts and Teaching Suggestions

Matter is made up of tiny particles called atoms. The human eye is unable to see an atom, but we can see them in mass as well as observe their actions in mass.

- Review the structure of matter as a basis for understanding nuclear energy.
- Demonstrate physical change by breaking calcium carbide with a hammer. When put into a small paper cup that is 1/4 full of water, bubbles of acetylene gas rise. This illustrates chemical change. If another paper cup with a 1/4" hole in the side near the bottom is inverted and slipped inside the first cup, a small explosion will result when a lighted match is brought to the hole. This is also an example of chemical change.

  $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

  Caution: Handle materials carefully. Use a face shield.
- Demonstrate electrolysis of water to show that water is a combination of hydrogen and oxygen in the ratio of 2:1. Use a few drops of H_2SO_4 to make the water a better conductor. Use the electrolysis apparatus.

Atoms are made up of combinations of protons, neutrons, and electrons.

- Illustrate the structure of an atom, using models and charts. Use charts and models to explain isotopes.

• RADIOACTIVITY

RADIOACTIVITY IS A PROCESS OF SELF-DISINTEGRATION OF CERTAIN ELEMENTS. WHEN THE BALANCE WITHIN THE NUCLEUS OF THE ATOM IS UPSET, RADIOACTIVITY OCCURS WITH ENERGY AND MATTER GIVEN OFF IN THE FORM OF ALPHA, BETA, AND GAMMA RAYS.

Concepts and Teaching Suggestions

Because of radioactivity, the atoms of some heavy elements are continuously breaking apart. Although we cannot see an atom, we can see and measure the results of its disintegration.

- Using the "Classmaster,"* show that there is no increase in radioactivity when a probe is brought close to calcium carbide reacting with water. Show that there is increased activity as the probe is brought close to a radium source. Caution: The G-M tube has an operating voltage at which it works to best advantage. Teacher should not put excessive voltage on the G-M tube, as this will permanently damage it. See instruction booklet, entitled "Teaching With Radio Isotopes," which is listed in references.

- Using a low-power microscope, look at the luminous dial of a watch in a darkened room. The zinc sulfide will give off light when struck by alpha particles which are released during the disintegration of radium.

- Demonstrate a cloud chamber. See Modern Science Equipment List. (Dry ice may be ordered from the Science Center.)

- Demonstrate the penetration of the radioactive ray. Place a radium watch dial face downward on photographic print paper in a light-tight package. Expose for 30 minutes. Develop the paper and observe results.

- Compare the rate of discharge of an electroscope when left alone and when a radium source is held a half-inch above the conductor of the electroscope. (Hence, a radioactive material gives off something that causes electrons to leave an electroscope.) (Avoid moist air when doing this experiment.)

---

*If you do not understand the operation of the "Classmaster," obtain directions from your department chairman.

• NUCLEAR ENERGY

• RADIOACTIVITY

The loss of mass of the atom, which can be weighted, represents the amount of energy released. The disintegration of the atom converts to a tremendous amount of energy.

- Discuss Einstein's mass energy equation ($E = mc^2$). Using models, diagrams, and films, show how fission takes place in U-235.

  Demonstrate a chain reaction, using 25 mouse traps with a cork attached to each trap by an 8" length of string. Show first with traps 3" apart and then when they are very close together. Notice how the first few neutrons (other corks) may not strike a U-235 nucleus (the trap's trigger).

If man can regulate disintegration in a radioactive substance, he can regulate the amount of energy given off.

- Discuss and show use of the atomic pile. Discuss problems of disposal of atomic wastes, heat-exchange control problems, and peaceful uses of atomic energy as a result of controlled fission.

An excessive amount of exposure to atomic radiation is lethal.

- Discuss the known physiological changes caused by excessive radiation.

We are receiving radiation all the time.

- Demonstrate "background radiation" with the Classmaster. (Do not exceed 1,000 volts on the G-M tube.)

- Discuss rays and particles given off by radioactive materials (Alpha particles, Beta particles, and Gamma rays) and their effect on human beings.

A person does not feel atomic radiation during the period that he is exposed to it. The more dense the material between the individual and the source, the less radiation is received by the individual. Lead is used to absorb radiation.

- Demonstrate the absorption of radiation by increasing the thickness of materials between the source and the probe. Plot a graph comparing the thickness of material with the amount of radiation that penetrates.

• RADIOACTIVITY

- Demonstrate the inverse square law by measuring the amount of radiation at various distances. Plot a graph on the blackboard.
- Discuss radioactive fallout and its predictability.
- Discuss the importance of civil defense activities, including "Conelrad."
- Display and demonstrate the Civil Defense kit. Explain uses of Geiger counters, Dosimeters, ion chambers, and similar devices.
- Suggest future enrollment in a civil defense class to become a radiological monitor.

Scientists working with radioactive materials must follow rigid safety rules.* Refer to Safety Handbook for list of precautions.

- Discuss safety rules concerning radioactive isotopes, such as the following:

    1. Avoid ingestion or inhalation of radioactive materials.
    2. Do not place mouth on pipette.
    3. Avoid contamination of hands. Wash hands after each experiment with radioactive isotopes; test with Geiger counter. "Contamination" can be removed with a "surgeon's scrub" and soap, used for 10 minutes by the clock.
    4. Conduct work under a ventilated hood if reactions which form radioactive fumes might occur.
    5. Use tongs or tweezers in handling containers or specimens. The amount of radiation received varies inversely with the square of the distance from the source.
    6. Keep radioisotopes under lock and key to avoid use by unauthorized persons.
    7. Caution: Do not allow probe of Classmaster to touch a radioactive source because it may become contaminated and give incorrect readings.

---

*Radioisotopes are available from the Science Center. Experiments with radioisotopes in Modern Science classes are for teacher demonstrations only.

• NUCLEAR ENERGY

• RADIOACTIVITY

Every known element has been made artificially radioactive.

- Discuss the work of the cyclotron and other "atom smashers." Show by diagram how the cyclotron works.

Many elements can be made radioactive for a period of time.

- Discuss "half-life." For example:

Phosphorus Chemical Form	Half-Life	Beta Energy	Gamma Energy
NaH_2PO_4	14.3 days	1.701	none

Radioactive isotopes have many uses in research and diagnosis.

- Place a small goldfish in 600 ml tap water containing 10 μc of p^{32} and some suitable fresh-water plants. After 3-5 days, dissect the fish and test the skeleton and various organs for radioactivity by means of the Classmaster or by a radiograph. (Teacher demonstration only.)

  Obtain 10 μc (microcuries) of p^{32}. Carefully wash the soil from the roots of two young tomato plants. Put the root of one in a bottle of water containing 10 μc of p^{32}. Wrap a lead shield around the bottle. Place the other tomato plant in fresh water. Take readings on the lower leaves and upper leaves on both plants. Make a graph to show the results. (Teacher demonstration only.)

  Ask a student to prepare a decay chart for 10 μc of p^{32} by taking readings every day for 3 weeks and by plotting the readings against the time elapsed. From this chart, estimate the half-life of p^{32}.

The hydrogen bomb is based upon fusion of heavy isotopes of hydrogen into helium.

- Show by diagrams the fusion of hydrogen.

In the future, fusion reactions may be a tremendous source of energy.

- Discuss fission versus fusion.

- Discuss problems involved in the control of fusion.

• TEACHER RESOURCES

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition

Experiment 39. Measuring Radioactivity

REPORTS

Use of atomic energy in transportation
The destructive power of an atomic blast
Decontamination of areas exposed to radioactive fall-out
Cancer diagnosis and treatment with radioactive isotopes
Producing radioactivity artificially (cyclotron, synchrotron)
Report on radioactive clocks
The hydrogen bomb
Where does the sun get its energy?
Civilian defense in atomic attacks

PROJECTS

Make models and diagrams of atoms.

Set a radium source (watch with radium dial) on a piece of unexposed film that is protected from sunlight by black paper. After a few days, develop the film. A radioactive material must give off some form of light energy that is very penetrating (more so than sunlight).

See how much radiation the exterior classroom wall has absorbed, compared with plaster walls in a home. Relate the results to the necessity of various bomb drills held at school.

Make daily radiation counts out of doors and in the classroom. Plot results. Account for variations, particularly for a sudden increase in the count.

AUDIO-VISUAL MATERIALS

Films

Fsd 541.38-1	"Isotopes"
Fsd 539.70.1	"Tagging the Atom"
Fsd 539.7-3	"Strange Case of the Cosmic Rays"
Fsd 541.2-5	"Report on the Atom"
Fsd 546.4-1	"Romance of Radium"
Fsd 541.2-12	"Self-preservation in An Atomic Bomb Attack"
Fsd 539.76-2	"The Atom Goes to Sea"
Fsd 355.23-9	"And A Voice Shall Be Heard!"
Fsd 540.2	"The Atomic Alchemist"
Fsd 539.76-1	"Atomic Furnaces"
Fsd 580-3	"The Atomic Greenhouse"
Fsd 541.2-3	"Atomic Power"
Fsd 553.4-1	"The Petrified River: The Story of Uranium"
Fsd 355.23-8	"New Family in Town"
Fsd 539.76-7	"Principles of Nuclear Fission"
Fsd 355.23-1	"Disaster Control"
Fsd 614.71-1	"Fallout; When and How to Protect Yourself Against It"
Fsd 622.338-2	"The Industrial Atom"
Fsd 614.8-66	"To Live Tomorrow"

Filmstrips

S-97	"The Atom"
S-63	"The Atom Theory"
S-14	"Atomic Physics" (5 filmstrips)
S-76	"Atomic Survival"
S-6	"Atoms As You Will Use Them"
S-95	"Nuclear Energy"
S-62	"The Structure of the Atom"
S-106	"The Wonder World of Science"

Pictures

S-3	"Peacetime Uses of Atomic Energy"

• TEACHER RESOURCES

Records

No. 133	"The Atomic Bomb"
No. 134	"Peacetime Uses of Atomic Energy"
No. 257	"The Nautilus Under the North Pole"

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. *Modern Physical Science*. New York: Holt, Rinehart, and Winston, 1962. pp. 589-619.

Pella, Milton O., and Aubrey G. Wood. *Physical Science for Progress*. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 143-153.

GENERAL REFERENCES

Olivo, C. Thomas, and Alan Wayne. *Basic Science*. Albany, New York: Delmar, 1957. pp. 380-392.

Lewelien, J. *The Atomic Submarine*. 1954.

Glasstone. *Sourcebook on Atomic Energy*. Latest Edition. Van Nostrand.

Miner, Shackleton, and Watson. *Teaching With Radioisotopes*. Washington, D. C.: U. S. Atomic Energy Commission, 1959.

• SOUND

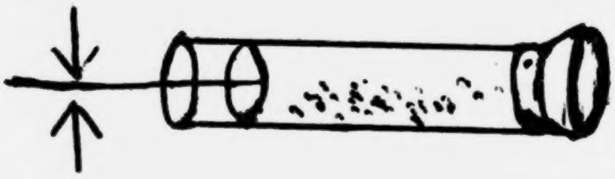
• NATURE OF SOUND

SOUND IS A FORM OF ENERGY WHICH MAKES POSSIBLE A MAJOR FORM OF COMMUNICATION IN OUR CIVILIZATION

Concepts and Teaching Suggestions

Something must vibrate to produce or transmit sound.

- Use a sonometer or violin to demonstrate vibrating strings.
- Show that a tuning fork vibrates by putting its vibrating prongs into water.
- Demonstrate a Kundt's tube, using a 3/4" diameter glass tube, cork to fit, cork dust, metal rod, clamp, rosin, and cloth. Show the standing waves and measure the wave length.



Stroke rod lengthwise with cloth containing a little rosin.

Sound is a form of energy which travels through matter in waves.

- Pour water to a depth of 1 inch in a flat glass dish. Place a light underneath the dish. Caution: Do not permit the light to be placed near the water. Put a screen above the dish so that waves on the surface of the water will be visible on the screen. Demonstrate that waves travel in all directions and can be reflected.
- Use a ripple tank to demonstrate the nature of waves. Use wave-projection apparatus (physics equipment). Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 40, "Waves In a Ripple Tank."
- Demonstrate a "slinky" (a long, flexible, coiled spring) to show the waves of compression and rarefication.

• NATURE OF SOUND

Sound waves travel in solids, liquids, and gases.

- Demonstrate that sound does not travel in a vacuum by removing the air from a bell jar containing an electric bell. (Obtain bell in jar apparatus and vacuum pump from physics stockroom.)
- Strike a tuning fork and put the handle to the table top while students hold their ears against the table.

Sound travels at different speeds through different substances.

- Borrow stop watch, a starting pistol, and blank shells from the physical education department. After careful instruction in proper use, ask student to go 1,000 feet or more from classroom but to remain visible and fire the pistol. When the gun is fired, measure the time between the flash and the sound. Try several times. Take an average. Measure the distance. Find the speed of sound.
- Perform as demonstration Experiment 32, entitled "How Fast Does Sound Travel?" See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition. This may be done as a laboratory assignment by the entire class, but it should be demonstrated first.

Sound varies in pitch, quality, and volume. Pitch is the frequency of vibration and varies with the size, tension, and length of the device producing the sound.

- By striking a hacksaw blade clamped to the edge of a table, show how sounds vary as the length of the rod is changed. Notice also visual and auditory changes in frequency and pitch.
- Fill bottles or beakers with water of varying amounts. Blow across the containers or strike them with an object. Notice the differences in pitch because of the varying water levels.
- Flatten one end of a soda straw. Clip off at an angle a piece on each side of the flat end. Blowing through the flat end will produce a sound. Cut the straw shorter and shorter to hear change in pitch as the straw is reduced in size.

- Use an oscilloscope and audio-oscillator to visualize the variation of pitch with frequency.
- Using an audio-oscillator (available on loan from Science Center) attached to a speaker (or earphones), demonstrate the audible range for the human ear and its variation among individuals.
- Discuss variations in audible range in animals.
- Arrange to have the school audiometrist talk to the class about variations in hearing range and how to test an individual's hearing.
- Using a rotator and a siren disk, demonstrate how the pitch rises as the speed of the disk increases.

Amplitude is the loudness of sound.

- Strike a bell with forces of varying degrees. Discuss decibel ratings.
- Discuss "sonic boom."

The quality of a tone depends upon the type of object vibrating and the characteristics of the frame to which it is attached.

- Compare the same note on the scale as played by 3 different instruments and as sounded on a tuning fork. Use the ear and an oscilloscope for the comparison. The musicians and instruments for the demonstration might be obtained from the music department. (Borrow oscilloscope from physics equipment.)

An echo is caused by reflected sound waves.

- Discuss the cause of echoes.
- Discuss the use of sonar for underwater surveying, detection, navigation, and communication.

- **NATURE OF SOUND**

Sound with frequencies above 20,000 VPS are called ultrasonics.

- Discuss uses of ultrasonics in industry and its future use in the home.
- Demonstrate the use of ultrasonics, if equipment is available.

Acoustics deal with sound waves.

- Show samples of acoustical tile.
- Discuss the relationship of design of buildings and auditoriums to the provision of good acoustics.
- Discuss reverberation.
- Discuss the loudness of sounds and their decibel ratings.
- Discuss how an automobile muffler works. Secure an old muffler and ask a student to take it apart.

Hearing is the response of the ear to vibrations and to the sensation produced in the brain.

- Borrow an ear chart and an ear model from a physiology class. Trace the pathway of vibrations through the ear.

MUSIC IS A PLEASURABLE FORM OF SOUND VIBRATION.

Concepts and Teaching Suggestions

Music is produced by materials vibrating at a regular frequency rate. Noise has an irregular frequency rate.

- Demonstrate this principle with a siren disk.

Noise and music can be distinguished by the wave pattern produced on an oscilloscope.

- Attach microphone to oscilloscope and show patterns of human voice and musical instruments.

Musical instruments are divided into three classes: string, wind, and percussion.

- Demonstrate instruments, such as violin, clarinet, and drums; or ask student musicians to play them.

Resonance is the ability of a vibrating object to pick up the energy of its own natural frequency; it is an important part of music.

- Demonstrate with mounted matched tuning forks.

- Demonstrate with a stringed instrument.

The quality of a musical tone is determined by the number and strength of overtones. A string will vibrate as a whole to produce what is called a fundamental; or it will vibrate in sections to produce overtones.

- Demonstrate with a sonometer or a stringed instrument. Show that the quality of the tone depends on overtones.

The musical scale consists of eight frequencies.

- Demonstrate these frequencies with tuning forks and point out the frequency of each fork.

• REPRODUCTION AND TRANSMISSION OF SOUND

GREAT ADVANCES IN COMMUNICATION HAVE RESULTED IN THE MORE EFFECTIVE TRANSMISSION AND REPRODUCTION OF SOUND.

Concepts and Teaching Suggestions

The phonograph, tape recorder, and dictaphone are devices for recording and reproducing sound waves.

- Borrow phonograph and tape recorder from school audio-visual department to demonstrate reproduction of sounds.
- Play records of different speeds.
- Demonstrate stereo effect with two speakers.
- Play an old 78 rpm record, then a new hi-fi stereo record. Discuss differences in sound.

In a telephone transmitter, sound vibrations are transformed into electric energy by variations in pressure on carbon granules by a thin vibrating diaphragm.

- Demonstrate telephone transmitter (stock number 735000 Modern Science non-consumable supply list).

The receiver duplicates the electric impulses produced in the transmitter and converts them into sound energy.

- Demonstrate how the telephone receiver operates. (stock number 725525 Modern Science non-consumable supply list)
- Demonstrate the principle by which the telephone transmitter functions.

  Fasten a wire to an iron washer and place in the bottom of a small thumbtack box. Cover with a layer of carbon particles. (Steel wool may be substituted.) Connect another washer, a small lamp, and dry cells in series. Place this second washer on top of the carbon and apply varying pressure. Observe the lamp.

• SOUND

• REPRODUCTION AND TRANSMISSION OF SOUND

Sound waves are transformed into electric energy in the mechanical or disk method of recording. The master disk is cut by the use of electric energy in vibrating a cutting head. This process is reversed in the playback as mechanical energy is changed back into sound waves.

- Point out how a needle is made to vibrate in the groove in a record at the same frequency and intensity as the original sounds.
- Discuss how stereo is recorded.
- Discuss the crystal pick-up.
- Demonstrate the use of a phonograph.

Tape recorders feed electric impulses onto a magnetic recording head. The pulsating magnetic field which is produced will induce a variation in the sound pattern on playback.

- Demonstrate the use of the tape recorder (available from the school audio-visual department).
- Take some tape recordings with the class.
- Discuss advantages of the tape recorder, such as portability, ease with which tape can be re-used, fidelity, and capability for instant playback.

Sound tracks and sound films make possible "talking" pictures. Sound waves are converted into electric vibrations, which in turn produce a changing light pattern which is photographed on a film. In playback, a light shines through the film, and the light energy is converted into electric energy.

- Show sound track on a film. Demonstrate the reproduction of sound, using the film projector.

The microphone is a device which converts sound waves into electric waves.

- Demonstrate use of a microphone (stock number 558100, physics equipment list).
- Point out that the different types of microphones include the carbon, crystal, capacitor, dynamic, and velocity.

- REPRODUCTION AND TRANSMISSION OF SOUND

The loud speaker changes electric waves back into sound waves.

- Show how a loudspeaker works. Point out how the vibrations of the paper disk set up sound waves.

- Point out that the different types of speakers include magnetic, permanent dynamic, and electrodynamic.

- SOUND

- TEACHER RESOURCES

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 32. How Fast Does Sound Travel?

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

REPORTS

Science of acoustics
Human ear and hearing aids
Sonar in bats
Sound recording and hi-fidelity
The telephone
Edison and the first recording of sound
Records and recording
Stereo and hi-fi
Microphones
Sound recordings for sound films and sound tracks
Tape recordings

PROJECTS

Make a tape recording or record.

Make various types of musical instruments.

Take apart and examine various kinds of sound-reproducing equipment from old record players, loud speakers, and microphones. Display and tell how each functions.

Collect samples of acoustical materials.

Using a kit, build a sound transmitting or reproducing instrument.

• TEACHER RESOURCES

AUDIO-VISUAL MATERIALS

Films

Fsd 785.1-5	"Exploring the Instruments"
Fsd 534-2	"Fundamentals of Acoustics"
Fsd 785.1-6	"Looking at Sounds"
Fsd 781.22-1	"Music as Sound"
Fsd 781-2	"Musical Notes"
Fsd 780.7-3	"Seeing Sound-Electronic Magic"
Fsd 534-1	"Sound Waves and Their Sources"
Fsd 781-1	"The Sounds of Music"

Filmstrips

S-148	"Sound Waves"
S-20	"How We Produce Sound and Speech"
S-154	"The Science of Musical Instruments"
S-106	"The Wonder World of Science" 1. Sonic and Supersonic Sound 2. Putting Sound to Work

Transcriptions

No. 292	"The Science of Sound" (24 min.)
No. 505B	"The Science of Sound" (30 min.)
No. 505C	"Sound Becomes Music" (30 min.)

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 443-469.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 333-368

• LIGHT

• NATURE OF LIGHT

LIGHT IS A FORM OF ENERGY WHICH MAKES THE WORLD VISIBLE. A KNOWLEDGE OF ITS BEHAVIOR IS BASIC TO THE UNDERSTANDING OF PROPER ILLUMINATION, SIGHT, OPTICAL INSTRUMENTS, AND PHOTOGRAPHY.

Concepts and Teaching Suggestions

Light is a form of energy emitted by excited atoms.

- Use a light meter to show that light is energy.
- Use a radiometer to show that light is a form of energy.
- Use a lighted candle or a solar battery to demonstrate that light is a form of energy.

Light comes from luminous or illuminated objects. We see non-luminous objects by reflected light. Some light is reflected by all surfaces, except those which have a perfectly black surface.

- Show a burning match or lighted candle to illustrate a luminous object.
- Point out that the moon is an illuminated object. Its illumination comes from a luminous body, the sun.
- Point out that all objects in the classroom which are visible are illuminated.
- Use a light meter to measure the amount of light reflected by the following: a mirror, substances with a smooth white surface and a rough white surface, objects of various colors, and black velvet. Use the same light source, light meter, and distances to compare light intensities.

Light travels in the form of waves, but at times it acts as though it consisted of particles. Light is a form of energy which travels in straight lines.

- Demonstrate that light travels in a straight line. Puncture three cards with a fine pin. Stand each card in a wooden block (or support with modeling clay). Line up the cards. Darken room. Use light source behind one of end cards. Light will pass through all three cards when they are exactly aligned.

- NATURE OF LIGHT

    - Demonstrate that sound waves will travel around an object, but that light waves will not. An opaque object in front of a light casts a shadow, while sound travels around the object.

    - Discuss the visibility of an object in a shadow if there is no air, such as on the moon.

When light waves strike a substance they may be reflected, they may be absorbed, or they may pass through the substance.

- Show the effect of light waves upon various materials that are

    a. opaque -- a piece of lead
    b. transparent -- a piece of glass
    c. translucent -- an oiled paper
    d. reflected -- a mirror

    Point out that light passes through a solid substance like glass, which is transparent, but that it is reflected or absorbed by other materials and surfaces.

Candle power is the unit used in measuring light intensity. A standard foot candle is equivalent to illumination on 1 square foot of surface held perpendicular at a distance of 1 foot from a standard candle. An ordinary candle has about one candle power.

- Demonstrate use of light meter (photoelectric type) or foot candle meter. Measure light intensities in various parts of the classroom. A concept photometer measures the intensity of a light and illustrates an application of the law that the amount of light reaching an object decreases with the square of the distance from the light source (inverse square law).

- Demonstrate use of a simple photometer. Use a piece of paper with a spot of oil in the center. When the paper is held to the light, the spot will appear bright. When the paper is held away from the light, the spot will appear dark.

    Two pieces of paraffin separated by a piece of metal also work well as a photometer.

- Demonstrate a Bunsen form photometer. Borrow from the physics stockroom.

• LIGHT

• NATURE OF LIGHT

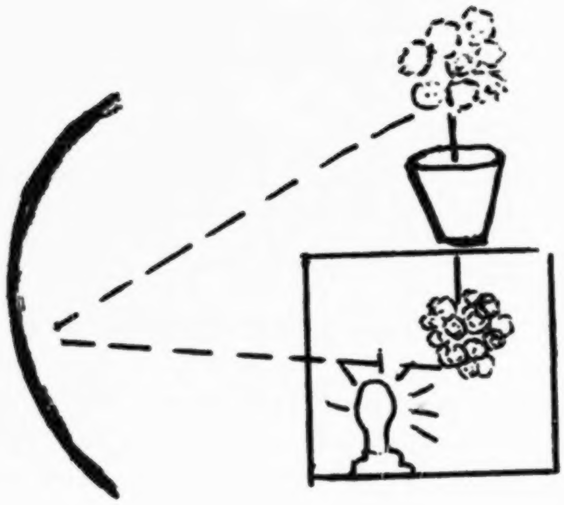
Light is reflected in a uniform way from a smooth, shining surface. The angle at which light is reflected from a mirror is the same as the angle at which it strikes a mirror. (The angle of reflection is the same as the angle of incidence.)

- Demonstrate this principle by using a large flat mirror so that the whole class can observe the reflecting qualities of the mirror. (The recommended size for the mirror is 14" x 24".)
- Place a small mirror at the bottom of a smoke-filled aquarium. Place a protractor next to the mirror. Cover the tank with a piece of cardboard in which a slit has been placed. Shine a light through the slit. Reflection of the light will be visible, and its angle can be measured. This demonstration may be performed as a student activity.
- Perform experiments using an optical disk borrowed from the physics stockroom.
- Students perform experiments. Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 33, "Where Is the Image in a Mirror?" This is an excellent laboratory activity for an entire class. Students may work in pairs or individually.
- Explain that a "virtual" image is formed with a plane mirror.

Concave mirrors form real images.

- Explain what a "real" image is.
- Place a lighted candle a few inches away from a concave mirror. Move a piece of paper back and forth in front of the candle and mirror until an image appears. This is a "real" image. This demonstration is also effective when done with a large parabolic mirror and a movie screen. A large inverted candle flame will appear on the screen. Place the candle close to the concave mirror. An enlarged candle can be seen in the mirror. This is a "virtual" image.
- Conduct the "phantom flower" experiment. Place an object and image at a location about twice the focal length from a concave mirror. The position of the object should be slightly below the optical axis of the mirror, and the image should appear to be slightly above. Flower supported in this position may appear to be in a flower pot.

• NATURE OF LIGHT



- Discuss some of the uses of concave mirrors in telescopes and automobile headlights and on solar furnaces.

- Use a series of plane mirrors to make a concave mirror.

Light is bent as it travels from one substance to another if the substances differ in optical density and the ability to transmit light. This is the principle of refraction. The index of refraction is the degree to which a substance can bend light.

- Place a coin in the bottom of an opaque cup. Ask a student to stand where he can just see the edge of the coin over the rim of the cup. Pour water carefully into the cup. Note when the coin appears. Discuss.

- Place a coin in a graduate cylinder. Fill with water. Observe the position of the coin in the graduate. It will not appear to be at the bottom. Discuss fishing and the observation of a fish in water. Discuss faceting of gems. Discuss the role of refraction in connection with a diamond's brilliance.

Polarization is a property of certain materials which permits them to transmit light along only one plane.

- Show filmstrip S-153, "Putting Light to Work," or film Fsd 535-3, "Light Control Through Polarization."

- Discuss use of polarization in polarized lenses, windshields, and headlights.

COLOR IS AN IMPORTANT DIMENSION IN OUR WORLD TODAY.

Concepts and Teaching Suggestions

Color is determined by the wave length of light.

- Present a chart to illustrate the electromagnetic spectrum and indicate the portion occupied by visible light.
- Explain how each color is of a different wave length.

The eye is sensitive to a very small range of the spectrum.

- Discuss a world of black, white, and gray in contrast with a world in which there are colors. Refer to use of color vs. black and white in television and films.
- Point out that ultra-violet light is not visible to the eye. (Ultra-violet rays are short waves.) Show an ultra-violet lamp (stock number 001404).
- Show an infra-red lamp, which gives off heat rays at the other end of the spectrum. (Infra-red rays are long waves.)
- Demonstrate characteristics of the eye, such as retinal fatigue, red-green color blindness, and persistence of vision. Refer to color plates in Brooks, Tracy, and Tropp, Modern Physical Science, 1962 Edition. page 500. Discuss why early films were called "flickers."
- Use Wescott slides for color blindness to show how an eye can be defective.

The prism will refract white light to produce a spectrum.

- Demonstrate the refracting ability of a prism. Use the Hartl disk and illuminator.
- Demonstrate defraction, which will bend light and disperse it into its color even better than a prism. Use a defraction grating.

- COLOR

An object's color depends on how it absorbs, reflects, or transmits light. White reflects all light.

  - Demonstrate this principle with various pieces of colored paper.

The mixing of pigments produces different results than does the mixing of light.

  - Use a rotator with colored disks to demonstrate the mixing of various colors.
  - Demonstrate a color mixer. Equipment for making several interesting demonstrations may be obtained from the school's stage craft instructor.
  - Obtain a water color paint box and demonstrate the mixing of pigments.

• LIGHT

• LENSES AND OPTICAL INSTRUMENTS

LENSES REFRACT LIGHT. THERE ARE TWO MAIN TYPES OF LENSES--THE CONVEX AND THE CONCAVE.

Concepts and Teaching Suggestions

The convex lens draws light rays together and is used in many optical instruments. A concave lens spreads light rays apart.

- Use the Hartl optical disk to demonstrate the path of light through a lens.
- Using just a magnifying glass and a piece of white paper, show how a convex lens focuses a clear, sharp, but small image.
- Show by diagrams on the chalkboard the paths of light rays through the concave and convex lens.

Convex lenses form images on a screen.

- Refer to Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 34, "Lenses Form Images."
- Demonstrate from this experiment how to find the focal length of a lens.

The eye is the human instrument sensitive to light. It contains a convex lens.

- Review parts of the eye and their functions: lens, iris, cornea, retina, and ciliary muscle.
- Discuss the lens of the human eye.
- Discuss correction of lens irregularity in the eye.

LENSES AND OPTICAL INSTRUMENTS

Lenses are used in a variety of useful optical instruments.

- Point out the lens systems of various optical instruments. For this demonstration, obtain such instruments as the following:

  Baloptican (opaque projector)
  Overhead projector
  Movie projector
  Microscope
  Camera
  Telescope
  Spectroscope
  Binoculars
  Periscope

- Demonstrate the spectroscope as an example of an instrument that can be used to identify elements.
- Use a clean platinum wire to burn a sodium compound in a Bunsen flame. A bright yellow flame from sodium atoms will be seen.
- Demonstrate the stroboscope.

• LIGHT

• PHOTOGRAPHY

PHOTOGRAPHS OFTEN TELL MORE THAN MANY WORDS. PHOTOGRAPHY HAS PROGRESSED AS AN IMPORTANT MEANS OF COMMUNICATION, EDUCATION, AND ENTERTAINMENT.

Concepts and Teaching Suggestions

There are many steps between seeing what you want photographed and obtaining the finished photograph.

- Demonstrate a pinhole camera having a ground glass back. An image can be easily seen when a piece of black cloth is put over the head so that no light falls on the ground glass. Repeat procedure, using a larger hole. Notice poorer focusing but brighter picture.
- Take a flash picture of the class with a polaroid camera. Remove the film from the camera and pass it around for the students to find themselves in the "picture." Repeat with a conventional camera. Send the exposed film to be developed.
- Develop a film in class, using the tank-type developer kit (a light, tight box with red cellophane over the front), or a dark room.
- Make a list of the basic items which the class members think would be needed to make a photograph.
- Expose a film to varying amounts of light by covering an unexposed film with a piece of black paper. Turn a light on the black paper. Remove the paper to expose an inch of the film. After a short interval, move the paper another inch to expose 2 inches. Continue, using equal time intervals, and develop.

Since white light is made up of all colors of light, any desired part of the colors of light may be selected by filters.

- Cast 3 shadows from a single opaque object, using 3 colored lights. Use illuminators and red, blue, and green gelatins obtained from the stage craft instructor. Moving the opaque object closer or farther from the lights causes the shadows to overlap. Six different colors, as well as white, may be observed.
- Examine various colored objects under white light, using red, green, and blue filters.
- Show identical colored photographs taken with different filters.

• PHOTOGRAPHY

To take a picture with two-dimensional qualities involves using a camera with two lenses. A camera with a single lens will take a picture as seen with one eye. A camera with two sets of lenses (stereo) will take two separate pictures--one with each lens set.

- Show a three-dimensional object (a box) drawn on a two-dimensional surface (chalkboard).
- Show a three-dimensional object (a box) and discuss the differences in lighting on the surfaces, as well as the simultaneous two points of view (one with each eye).

A projector with two sets of lenses (stereo) will superimpose two pictures on the screen. A polaroid filter will separate these pictures into two images--one for each eye.

- Demonstrate polaroids by projecting a picture through one polaroid. Mount the polaroid in front of the projector lens. Look through another polaroid while rotating its axis.

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 33. Where Is the Image in a Mirror?
" 34. Lenses Form Images
" 40. Waves in a Ripple Tank

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

REPORTS

Infra-red photography
Lasar
The speed of light
Light: wave or particle?
Movies and optical illusion
Color film by the Kodacolor process and by the Ansco color reversible process
Photography by ultra-violet, infra-red rays, and X-rays
Various types of cameras: box, reflex, view, portrait, and motion picture
Use of lenses in correcting eye defects
Corrective lenses
Contact lenses
Color

• TEACHER RESOURCES

PROJECTS

Visit a mirror and glass shop. Obtain samples of various types of glass used in mirrors.

Resilver a mirror (See Appendix for formula.)

Build a solar furnace which uses a large parabolic mirror.

Make an optical instrument, such as a periscope or microscope, from simple materials.

Construct a smoke box to show the action of lenses.

Start a photography hobby.

Build a telescope and observe the night sky. Report on your observations.

Build a photographic dark room, and develop and print pictures.

AUDIO-VISUAL MATERIALS

Films

Fsd 778.2-2	"Carbon Arc Projection"
Fsd 770.2-1	"Developing the Negative"
Fsd 535.6-6	"Discovering Color"
Fsd 535-5	"Learning About Light"
Fsd 535-2	"The Nature of Light"
Fsd 778-3	"Quicker'n A Wink" (Stroboscope)
Fsd 770.2-2	"Printing the Positive"
Fsd 531.33-1	"Similarities in Wave Behavior"
Fsd 537.12-2	"Simple Waves"
Fsd 535-3	"Light Control Through Polarization"
Fsd 535-1	"Light Waves and Their Uses"

Filmstrips

S-152	"Physics for Today" (2 filmstrips): "Light and How It Is Reflected" "Light and How It Is Refracted"
S-153	"Putting Light to Work"
VE-171	"Photographic Darkroom Procedures"
S-105	"What Is Color?"

FIELD TRIPS

Interested students may plan a trip to the photography department of a junior college. The trip could be arranged after school hours.

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 471-505.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 369-397.

GENERAL REFERENCES

Dull, Metcalfe, and Williams. Modern Physics. New York: Holt, and Rinehart. pp. 299-379.

Olivo, C. Thomas, and Alan Wayne. Basic Science. Albany, New York: Delmar, 1957. pp. 290-322.

Joseph, et al. A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. pp. 447-495. (Many demonstrations and projects are related to light.)

BLANK PAGE

• ELECTRICITY

• BASIC ELECTRICITY

ELECTRICITY IS A FORM OF ENERGY WHICH CAN BE CHANGED INTO OTHER FORMS OF ENERGY TO OPERATE MACHINES, PRODUCE CHEMICAL CHANGES, AND PRODUCE HEAT AND LIGHT. TRANSPORTATION, COMMUNICATION, INDUSTRY, AGRICULTURE, AND THE HOME DEPEND ON ELECTRIC POWER.

Concepts and Teaching Suggestions

Electric current is a flow of negatively charged electrons through a conductor.

- Simply switch a light on and off. Discuss the flow of current which can be turned on and off at will.
- Discuss the advantages of being able to control the flow of current to the locations where it is needed.

In direct current (D.C.), the electrons flow in one direction all the time (as shown by a galvanometer).

- Using copper wire, connect two pieces of metal, such as copper and zinc, to a galvanometer. A weak electric current will flow when the metals are put slowly into a lemon, the mouth, or very dilute acid. (Caution: Do not permit the strength of current to increase to the extent that the needle will go off the galvanometer scale.) Use suitable resistance if necessary.
- Make a voltaic cell by placing a strip of copper and a strip of zinc in a dilute solution of sulfuric acid. Connect the copper and zinc strips to a galvanometer or voltmeter and determine if any electricity is being produced. Replace the measuring instrument with an electric door bell. How long is it before the bell stops ringing?
- Try solutions other than H_2SO_4, such as distilled water, salt water, or vinegar. Try other strips of metal. Also note whether any charges register on the galvanometer.
- Show a dry cell which has been cut in half. Discuss the chemical action which produces a direct current.
- Discuss reasons why a dry cell becomes dead and how it can be reactivated. (Recharge by punching holes in the container and placing a dry cell in a solution of salt or sal ammoniac.)

- **BASIC ELECTRICITY**

  - Discuss the difference between a cell and a battery. Discuss the storage battery. Show a cut-away section of a battery. Ask why storage batteries need periodic inspection.

  - Explain the chemical action involved in producing a direct current.

In alternating current (A.C.), the electrons flow back and forth (as shown by a galvanometer).

- Make a simple coil of 20 turns of insulated wire. Attach the two ends to a galvanometer. Point out that regardless of the way a magnet is put through the coil, the galvanometer will show that the electron flow alternates.

- Discuss the relationships between magnetism and induced electric currents.

To produce electric energy, some other form of energy must be used.

- Discuss the way in which electricity is produced for Los Angeles (hydroelectric, steam, and atomic plants). Discuss the energy changes involved.

- Discuss the speed of electron flow from hydroelectric or steam plants.

- Demonstrate a thermocouple. Cut 2 copper wires and 1 iron wire 18" long. Twist 1 end of a copper wire around an end of an iron wire. Twist the other copper wire around the other end of the iron wire. Attach the free ends of the copper wires to a galvanometer. Put one of the twisted ends in ice water and the other twisted end in the flame of a Bunsen burner. Note increased current with increased heat. Several of these thermocouples may be hooked together in series to increase the current.

• ELECTRICITY

• BASIC ELECTRICITY

Electrons flow more easily through some materials than others.

- Connect a D.C. ammeter having a wide range of sensitivity, a variable resistor, a 1½-volt battery, and samples of materials in series. The samples of materials should include copper, iron, nichrome, carbon, and glass tubing. Find out how well each of these substances conducts electricity as the variable resistor is reduced. The length of these materials should be about the same and such that the nichrome wire becomes red hot when the variable resistance is zero. Also note how much current will pass through a human when a 1½-volt battery is used. List safety precautions in using electricity at home.

Ohm's Law provides a simple description of the way in which electricity behaves. It is one of the most important laws regarding electricity.

- Discuss how to use this law.

$$\text{Current in amperes} = \frac{\text{Electromotive force in volts}}{\text{Resistance in ohms}}$$

Man is a fair conductor of electricity. He can very easily draw enough current to cause his death from 110 volts.

- Show the action of electricity on the leg of a freshly killed frog. Point out that a human who grasps a current-carrying wire cannot release it because the muscles are held in contraction. Discuss first aid for electric shock.

A material that resists the flow of electrons becomes hot.

- Remove the glass from a good incandescent lamp by wrapping it first in cloth and then striking it against a table. Examine the filament. If the filament is broken, attach it to the electrodes. Screw the light into a disconnected light socket and then turn it on and examine. Caution: Be sure to turn off the switch before removing.

- Show the usefulness of the application of this principle in toasters, ironers, and other appliances.

• BASIC ELECTRICITY

Although electric wiring is often complicated, there are in reality only two kinds of circuits--parallel and series, or combinations of them.

- Demonstrate the two kinds of circuits. Christmas tree lights connected in series provide a good demonstration.
- If a circuit board is available from the physics stockroom, use it to display series and parallel circuits.
- Connect three dry cells in series and attach to a voltmeter. Show that the voltages are added. Connect three dry cells in parallel. Show that there is no increase in voltage. (See Brooks, Tracy, and Tropp, Modern Physical Science, page 514.)
- Discuss the short circuit.

Electric power is measured in watts. Power (watts) is equal to the pressure forcing the electron (volts) times the rate of flow of electrons (amperes).

Watts = Volts X Amperes

- Connect an A.C. meter in series with a 10-amp fuse. Connect these in parallel with 5 electric sockets. Plug into a 110-volt circuit. Screw in lights or plug in appliances of known wattage (stamped on all appliances) in various combinations. Find out how much electricity each appliance utilizes separately and compare their calculated total to the ammeter reading.

When too many amperes (electrons) are utilized, the wires become hot and the fuse melts. A fuse melts more easily than copper.

- Intentionally blow out the 10-amp fuse by overloading. Ask students to explain the action of the fuse. Relate to the danger of overloaded circuits.

Magnetism is related to electricity.

- Show some examples of a natural magnet, like lodestone.
- Demonstrate the effect of a bar magnet on a magnetized needle. Point out that opposite poles attract and like poles repel.

- Show the magnetic field of a magnet by placing a piece of paper on top of the magnet and sprinkling iron filings over the top.

- Demonstrate how various substances respond to a magnet.

- See Brooks, Tracy, and Tropp, Workbook for Modern Physical Science, 1962 Edition, Experiment 37, "What Can We Learn About Magnets?", which will provide additional demonstrations.

- Discuss the fact that the earth has a huge magnetic field. Relate to the Van Allen radiation belts.

When an electric current passes through an insulated wire wrapped around a piece of iron, the iron acts as a magnet. When the current is cut off, the iron no longer acts as a magnet.

- Make a simple electromagnet.

- Use a small compass to show that a magnetic field is produced when current is flowing through wire.

- Show that reversal of the current reverses polarity.

- Show by a diagram on the chalkboard the circuits involved in an electromagnet, such as in a buzzer.

- Demonstrate a lifting electromagnet (secure from the physics stockroom).

The electromagnet has many applications in the home, such as in the door bell, the telephone, the refrigerator, and the automatic washer.

- Show electromagnets in a buzzer, loudspeaker, telephone, earphone, and other equipment.

- Describe the action of the St. Louis motor. Ask students to connect the motor to a switch. Check the results.

- With the students, trace the electron path in an electric bell.

• BASIC ELECTRICITY

A transformer will charge the current or the voltage to the strength which is needed.

- Demonstrate the use of a step-up transformer to obtain higher voltage (less current).
- Show a Jacob's ladder.
- Point out uses of the step-up transformer for fluorescent lighting in the home.
- Using a bell transformer and a voltmeter, show how a 6-volt electric bell may be used on a 110-volt line.

ELECTRICITY IS A VITAL SERVANT IN TODAY'S HOUSEHOLD.

Concepts and Teaching Suggestions

Electricity used in the home is measured in kilowatt hours.

- Use the watt hour meter to measure watt hours used by an appliance. Compare readings with the results obtained by calculation.

Some appliances (radio, clock) draw very little current, while others (toaster, iron, rotisserie) draw a great deal.

- Ask students to draw a picture of the dials on their electric meter at home on a given day and again one week later. Show the students how to read the dials and to calculate the cost of electricity used in their homes for one week.
- Show an electric light bill for a home. Point out the number of kilowatt hours used and the cost of electricity.

The cost of running an electrical appliance can be easily calculated.

- Ask a student to determine the cost of using an electric clock or some other electric appliance for one year.

The path or flow of electrons can be easily traced in many appliances.

- Using discarded appliances (other than radios), trace the path of the conductor. Students should be able to take the appliance apart and put it back together.
- Demonstrate simple repair of appliances and replacement of heating elements. An ohmmeter or a battery in series with an ammeter is a good preliminary tester. (An appliance dealer or an electric repair shop can usually provide worn out equipment.)

• HOME ELECTRICITY

The thermostat is a simple automatic device to control the flow of electricity and thus to regulate the temperature of the appliance (coffee maker, iron).

- Demonstrate a compound or bimetal bar hooked-up in series with an electric heater. Focus the heat on the compound bar, if it is not very sensitive, to demonstrate its thermostatic action.
- Point out the precaution on the thermostat section of an electric coffee maker which reads, "Do not immerse in water."

The electric cord is a simple thing to repair or replace.

- Demonstrate the repair and replacement of an electric cord.

  Remove cord from an appliance, and point out the type (asbestos, rubber, plastic). Remove the plug. Cut the ends of the cords, restrip, and replace. Provide instruction on tying the underwriter's knot. Stress that careful inspection of the cord must be made to assure that it is safe to use again.

The size of a wire should be a factor in selecting an extension cord.

- Conduct an experiment using different samples of the same material, such as copper, but with different diameters. Temperature changes can also be noted

A worn extension cord is dangerous and could cause a fire or electric shock.

- Review first aid for electric shocks and their prevention.
- Refer again to the proper use of fuses or circuit breakers in the home.
- Discuss the significance of the UL seal on electric appliances.

SUPPLEMENTARY DEMONSTRATIONS AND PROJECTS IN ELECTRICITY

(May be assigned as student projects, or performed as teacher demonstrations.)

Make a lead storage cell that can be recharged. Cut 2 lead strips about 2" x 8" and sandpaper the surfaces. Put strips into a battery jar half-filled with dilute sulfuric acid. Fasten wires and connect to a voltmeter. Notice that there is no evidence of a current. Connect the cell to a 6-volt D.C. source (dry cells or battery eliminator). Pass current through the solution for several minutes. Observe chemical action on lead plate and positive pole. Disconnect direct current source, reconnect to voltmeter, and read the voltage. Storage cell can be discharged again by allowing it to ring a bell.

Make a model generating station. Connect a water motor, available in the physics stockroom, to a 6-volt generator. Use a large rubber band as a drive belt and use the output of the generator to light a lamp or ring a bell. Long transmission lines provide a more realistic demonstration.

Demonstrate the use of a photo-electric cell. Demonstrate the use of the photo-electric cell in ringing a bell, starting a motor, and turning off a light. Discuss applications in opening a garage door, supermarket door, and elevator door. (Stock number 002000, Modern Science Equipment List.)

Make a simple galvanometer. Wind a coil of No. 22 magnet wire 20 times around a jar 3" in diameter. Remove the tape so it will not unwind, and attach wire ends to binding posts. Support the coil with a piece of wood. Suspend a magnetized needle or razor blade within the coil so it will swing freely. Connect a dry cell to the galvanometer and observe its action. An even more simple galvanometer can be devised by winding a coil of wire around a compass.

Demonstrate the principle of an induction coil. Use an iron bolt or rod about 6" long. Wind 20 to 30 turns of magnet wire around one end and connect the ends to a galvanometer. (This is the secondary.) Wind a similar coil around the other end of the rod and connect it to a dry cell so that the circuit can be closed and opened (A.C. current). Relate to the ignition system of an automobile.

Make a demonstration kilowatt-hour meter board, using wooden "tinker-toys."

• TEACHER RESOURCES

CLASS EXPERIMENTS

Brooks, Tracy, and Tropp. Workbook for Modern Physical Science. 1962 Edition.

Experiment 37. What Can We Learn About Magnets?
" 35. Electric Current From Cells
" 36. How Much Current Flows Through a Wire? (Teacher demonstration)
" 38. How Do You Make an Electromagnet?

Pella, Milton O., and Aubrey G. Wood. Laboratory Manual and Study Guide - Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. Useful with slow groups. Select appropriate exercises.

REPORTS

The solar battery
Strontium 90 battery
Electricity from the energy of an atomic pile
Electroluminescence in home lighting
Electromagnets at home
Electromagnets in industry
The earth's magnetic field
Magnetism

PROJECTS

"Dissect" an old automobile generator. Point out the field coils, rotating coils, brushes, and computator segments.

Assemble a model generating station, using a water motor.

Take apart an old storage battery. Identify the parts.

Make a simple electric motor.

Take apart a number of switches, such as the simple knife switch, the toggle switch, and the push button switch, and describe how they are used.

Take apart various old electric appliances and investigate their construction and circuits.

Make a simple galvanometer.

Make some breadboard circuits to demonstrate series and parallel circuits.

Map the wiring circuit of your home.

AUDIO-VISUAL MATERIALS

Films

Fsd 621.31-10	"Blueprint for Power"
Fsd 537.5-4	"Current and Electromotor Force"
Fsd 541.37-1	"Electrochemistry"
Fsd 537.2-1	"Electrostates"
Fsd 537-4	"Elementary Electricity"
Fsd 324-2	"Thunderbolt Hunters"
Fsd 621.3-7	"Light and Power"
Fsd 537-2	"What Is Electricity?"
Fsd 621.3-5	"The Electrician"
Fsd 643.7-1	"Home Repair"
Fsd 621.2-2	"Power by Which We Live"
Fsd 621.31-11	"Power for Progress"
Fsd 621.35-1	"Primary Cell"
Fsd 537-3	"Principles of Electricity"
Fsd 671-8	"Nerves of the Nation"

Sound Filmstrips

No. 483	"New Concepts in Lighting"

• TEACHER RESOURCES

Filmstrips

VE-32	"Alternating Current"
VE-27	"Current Electricity"
VE-24	"Distributing Electric Power"
VE-28	"The Electric Cell"
VE-34	"Electric Meters"
VE-33	"Electric Motors"
VE-30	"Electromagnetism"
VE-31	"The Generator"
VE-25	"Magnetism"
VE-26	"Static Electricity"
VE-4	"Home Repair Series" (2 sets) 1. "Electrical Repairs" 2. "Electrical Repairs"
S-150	"Electrical Circuits"
S-71	"Electricity"
S-15	"How Water Power Produces Electricity"
S-151	"Principles of Electric Motors and Generators"
S-155	"What Is Magnetism?"

FIELD TRIPS

For selected groups of students
Los Angeles City Dept. of Water and Power Electric Living Center
4030 S. Crenshaw Blvd., Los Angeles

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 507-545.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 235-267.

GENERAL REFERENCES

Olivo, C. Thomas, and Alan Wayne. Basic Science. Albany, New York: Delmar, 1957. pp. 177-245.

Dull, Metcalfe, and Williams. Modern Physics. New York: Holt, and Rinehart.

• ELECTRONICS

• ELECTROSTATICS

ELECTRONICS IS A BRANCH OF SCIENCE THAT DEALS WITH CONTROL AND UTILIZATION OF ELECTRON STREAMS. ELECTRONIC TUBES HELP DO MANY JOBS, INCLUDING CONTROLLING MACHINERY, DIAGNOSING ILLNESSES, PROVIDING ENTERTAINMENT, MAKING COMMUNICATION POSSIBLE, AND SOLVING COMPLEX MATHEMATICAL PROBLEMS.

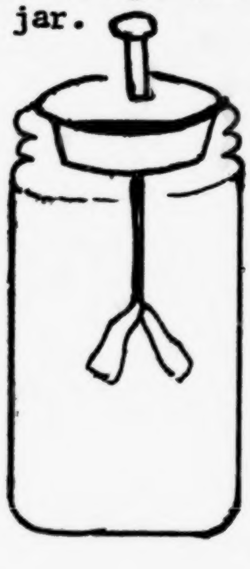
Concepts and Teaching Suggestions

A study of static electricity can help students to understand the action of the electron. Static electricity is the piling up of electrons or the removal of electrons from non-conducting material. This type of electricity is produced by friction, or the rubbing together of dissimilar objects. It is present at all times, although sometimes it is more obvious than at other times.

- Perform a number of experiments with electrostatics.
- Charge a hard rubber rod on fur or wool. Ask each student to charge his comb by combing his hair and then to pick up tiny pieces of paper with the comb.
- Charge a rubber rod and place it near a small stream of water from a faucet. Note deflection of water. Charge a rubber rod again. Hold it near an expanded balloon. Note action of balloon.

Static electricity is the piling up of electrons or the removal of electrons from a non-conducting material. Current electricity is a continuous flow of electrons. The electroscope detects electric changes.

- Use a support from which 2 pith balls are suspended. Charge a hard rubber friction rod with cat fur and demonstrate to the class the electronic principles of repulsion, attraction, and grounding.
- Demonstrate the use of a gold-leaf electroscope.
- Show how an individual electroscope can be made using thin plastic wrap for leaves, cork, copper wire, and small jar.



- **ELECTROSTATICS**

  - Show how a Leyden jar "stores up" electrons and acts as a condenser (also called a capacitor).

  - Take apart different types of capacitors from an old radio or television set to show construction. Explain their general use.

The electrostatic generator is capable of producing large static changes.

  - Demonstrate the use of a static machine, Wimhurst type (Modern Science equipment list, stock number 002378).

  - Perform various experiments with the electrostatic generator.

  - Obtain electrostatic accessories, such as the plume and whirl, from the physics stockroom. Use them with the generator.

  - Place pith balls in a 3-inch length of clear plastic tubing which is 2" in diameter. Cover both ends with aluminum foil. Place on top of the generator, and observe the pith balls move up and down.

    Cut a triangular piece of aluminum foil about 2" long and ¼" wide at the base. Give it a quarter turn, and hold the tip about a foot from the generator. The foil will be snapped up and go into "orbit" about the lower edge of the terminal.

    Ask students to suggest other experiments. Attempt to explain in terms of electron flow.

  - Wet a string with salt water and attach to the ball of the electrostatic generator. Turn on the machine. Electrons will flow down the string. Point out how this shows that electrons will flow along a conductor.

Electrostatic principles are used in smog abatement and for other purposes.

  - Discuss how negative and positive charges are used in air purification and in making sandpaper and certain textiles.

• ELECTRONICS

• VACUUM TUBES AND SEMI-CONDUCTORS

VACUUM TUBES AND SEMI-CONDUCTORS REGULATE ELECTRON FLOW AND ARE MAJOR COMPONENTS OF ELECTRONIC EQUIPMENT.

Concepts and Teaching Suggestions

Electrons will move rapidly between the electrodes of a partially evacuated tube under moderately high voltage. The electrons striking the remaining air molecules will cause them to glow.

- Attach a gas-filled tube with suitable electrodes to an induction coil. The discharge through this tube should produce a luminous effect. (Use Geissler tube or neon tubes.)

- Discuss later development of these tubes in neon, fluorescent, and vapor lamps.

- Demonstrate the vacuum tubes available in the physics stockroom (Cathode ray tubes, and Crookes tube).

In a high vacuum, the glow disappears because the air molecules are not being struck by electrons. The electrons are still flowing and strike the glass or any other obstacle in their path. The high impact causes the emission of high-frequency radiations called X-rays. If a fluorescent screen is near, the fluorescent materials will glow when the electrons strike it.

- Demonstrate with the Crookes tube or Cathode tube, if they are available in the physics stockroom.

- Demonstrate how the electron stream will cause glass to fluoresce and how the stream can be deflected by a magnet.

- Demonstrate use of the oscilloscope. Show and explain by diagram how one stream of electrons hitting a fluorescent screen can be deflected by magnets.

- Suggest that students obtain a good picture on their television sets at home, and then place a strong magnet by the screen. Ask them to note the distortion caused as the electrons are affected by the magnet.

- VACUUM TUBES AND SEMI-CONDUCTORS

  - Obtain an old television tube and point out its relationship to the oscilloscope.
  - Display old X-ray tubes.
  - Ask class members to explain how the X-ray tube or television tube works.
  - Circulate in the class an electron gun from an old television picture tube.

When some metals are heated, electrons are given off. This action is called thermionic emission and is the principle underlying the operation of radio tubes. This principle was discovered by Thomas Edison and was called the "Edison Effect."

- Show by diagram on chalkboard the Edison Effect principle.

The diode, the simplest of all electron tubes, contains two elements, the filament or cathode, which gives off electrons, and a plate.

- Show a diagram of a diode.

The triode has a grid between the cathode and the plate. In the radio receiver a triode acts as an amplifier.

- Show by a diagram how the grid controls the flow of electrons from cathode to anode.
- Discuss the function of various radio tubes (e.g., diodes change alternating to direct current).
- Ask students to bring old radio tubes to class and to "dissect" them.

The transistor is a tiny non-vacuum tube made of a material called a semi-conductor (neither a conductor nor an insulator). A typical semi-conductor is germanium. When pure arsenic is added to germanium, it will give off electrons. When indium is added, it will attract electrons. Properly arranged, these materials can be compared to the triode vacuum tube, but transistors operate on very low voltage and are smaller and more rugged.

- Show several examples of transistors.
- Draw a diagram of a transistor on the chalkboard, and point out the emitter, base, and collector.
- Discuss construction of selenium rectifiers, crystal diodes, and tunnel diodes.
- Show some of these components in a radio circuit, such as in a small transistor radio.

Maser (micro-wave amplification by stimulated emission of radiation) is the first true amplifier of radio waves or light rays. It amplifies electromagnetic waves and not electric currents. Maser comes in glass-filled tubes or solid-state materials. Electrons are excited to high energy by micro-waves and these excited electrons give off excess energy.

- Demonstrate micro-wave apparatus if available.

Radar (radio detection and ranging) micro-waves are wave lengths of a few inches or less, contrasted with the radio waves of hundreds of feet in length which are used in broadcasting. The radar micro-waves are superior to longer waves in picking out distant targets.

- Discuss the uses of masar and radar in our civilization.

• RADIO AND TELEVISION

RADIO AND TELEVISION SETS ARE EXAMPLES OF THE PRACTICAL APPLICATION OF ELECTRONICS. RADIO AND TELEVISION PROVIDE IMPORTANT MEANS OF COMMUNICATION AND ENTERTAINMENT.

Concepts and Teaching Suggestions

The transmitter changes sound waves to electric impulses and then to radio waves (low energy light waves), which are easily transmitted.

- Use an oscilloscope and a microphone (earphones will work) to show how sound waves can be changed to electric impulses.

The receiver changes radio waves to electric impulses and then to sound waves.

- Use a radio demonstrator to illustrate the use of a radio receiver.

- Attach an oscilloscope to the various stages of a radio receiver to show how the equipment amplifies the weak radio waves that it receives.

- Use a radio as a loud speaker by attaching a microphone to the grid of the audio-amplifier stage.

Broadcasting by FM has certain advantages over AM, as well as certain disadvantages.

- Diagram the difference between amplitude modulation and frequency modulation.

- Show how the AM waves, which are of a lower frequency, are reflected by the ionosphere, whereas most FM waves are not. Television transmission uses FM waves and, hence, has only a 70-to 100-mile range.

- If possible, discharge an electric spark, using a spark coil or a static machine in the vicinity of an AM receiver. Notice how the static is picked up. Conduct the same experiment with an FM receiver.

Light energy can be converted into electric energy.

- Demonstrate a phototube and point out its use in television cameras and in automatic door openers for markets. Other uses include light meters and automatic counting devices.

Television involves remarkable speed and precise electric synchronization.

- Deflect an electron beam in an oscilloscope or a television receiver with a weak magnet to show how scanning of the electron beam may take place.

- Instruct students to inspect the television picture closely with a magnifying glass.

Color television is produced by the use of three cameras and three electron guns producing three electron streams. These cause three different minerals on the inner face of the tube to fluoresce and produce the different primary colors.

- Discuss the operation of colored television.

Unit 10

• AUTOMATION

AUTOMATION IS THE AUTOMATIC CONTROL OF THE OPERATION OF A PROCESSOR SYSTEM, ESPECIALLY BY ELECTRONIC DEVICES. THERE IS AN INCREASING USE OF AUTOMATION IN INDUSTRY.

Concepts and Teaching Suggestions

Automatic devices in use today are increasing productivity and making work easier.

- List and discuss examples of common automatic devices, such as photoelectric cells to open doors, IBM machines, and electronic computers.
- Demonstrate a thermostat as a mechanical means of controlling a heating system. This is a means of self-regulation.

Automatic control of machines will result in the substituting of human labor and human control by mechanical labor and mechanical control.

- Present and discuss a flow chart illustrating a typical automated production line.
- Present and discuss flow charts of specific operations.
- Point out various automated industries depicted in films shown during the semester.

Automation will have a great effect on our lives. Scientific advances in industry have always led to more jobs--not fewer.

- Discuss foreseeable advantages and disadvantages of automation, such as the following:
    1. Elimination of many tedious routine operations
    2. Creation of new and more interesting jobs
    3. Increases in productive capacity of industry
    4. Production of a greater variety of goods
    5. Higher standards of living
- Organize debate or round-table discussions on the question, "Will automation lead to wide-spread unemployment?" (Other topics can be suggested.)

CLASS EXPERIMENTS

Supplementary Laboratory Activity (See Appendix)

Experiment 10. Electrostatics page 185

REPORTS

Color television
Proximity fuses
Radar
Radio astronomy
Radar control of speed
Electronic microscope
Electronic computers
Transistors
Printed circuit wiring
Solar batteries
Tunnel diodes
Smog abatement and electrostatics
Electrostatics in the sandpaper and textile industry

PROJECTS

Compare the specifications on frequency reproduction of several phonographs, amplifiers, and speakers. Circulars are available at most radio and hi-fi shops.

Build from a kit any type of electronic device.

AUDIO-VISUAL MATERIALS

Films

Fsd 621.385-4	"Story Without End"
Fsd 621.38-6	"The Bottle of Magic"
Fsd 621.32-2	"Electronic Light"
Fsd 621.38-3	"Electronics at Work"
Fsd 621.34-1	"The Transistor"
Fsd 621.388-4	"Television--Land of New Frontiers"
Fsd 625.1-2	"Railroading With Radar"

• TEACHER RESOURCES

Films

Fsd 621.38-15	"The New Giant"
Fsd 621.388-3	"The Magic in Television Tubes"
Fsd 621.385-5	"Mobile Telephones"
Fsd 658.56-1	"This Is Automation"

Filmstrips

VE-12	"Television Receivers"
VE-2	"The Television System" (Principles of television broadcasting)
S-69	"What Is Electronics?"
S-89	"Calling Your Neighbor" (Telecommunication)
S-156	"How Color Television Works"
S-74	"How Television Works"

FIELD TRIPS

Refer to It's Worth a Visit to select field trips.

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 547-587.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 350-367.

GENERAL REFERENCES

Buban, and Schmitt. Understanding Electricity and Electronics. New York: McGraw-Hill, 1962. (Has descriptions of many excellent projects with simple diagrams)

Olivo, C. Thomas, and Alan Wayne. Basic Science. Albany, N. Y.: Delmar, 1957.

Joseph, et al. A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. pp. 534-555.

• SPACE

• WHAT IS SPACE?

THE MOST IMPORTANT EVENT THAT HAS OCCURRED IN OUR GENERATION IS THE BEGINNING OF THE SPACE AGE.

Every facet of the human mind is seeking to answer such questions as, "What is out there,?" and "How can 'earth-bound' man survive out there?". Space is a great unknown.

Astronomy, physics, chemistry, mathematics, biology, physiology, earth science--in fact, all organized sciences--are being used in search for the answers to questions of this kind. Bio-astronautics, bio-dynamics, and bio-avionics are new sciences through which answers are also sought.

Money, manpower, mineral resources, and industrial might are all involved in the race for space leadership.

The greatest search today is for untapped sources of human imagination. What may seem to be a wild dream or a foolish idea may hold the key to the future of man and his civilization in the universe and on the planet earth.

Concepts and Teaching Suggestions

Man's basic curiosity about the earth and the universe surrounding his planet has initiated the conquest of space.

- Obtain a globe of the earth and discuss in general man's place in space.
- Use planetarium and charts on space in the discussion.

The most intense studies of the earth have resulted from the work during the International Geophysical Year, and have provided man's investigation of space a tremendous boost.

- Discuss the 13 areas incorporated in the work of the I.G.Y. Each area might be assigned for special reports, including:

The Earth's Magnetism (geomagnetism)
Auroras
Cosmic Rays
Glaciers
Gravity of the Earth
Measurements of the Earth's Dimensions
Rockets and Artificial Satellites
The Ionosphere
Oceans
Earthquakes
Weather (Meteorology)
Activity of the Sun
Radioactivity and Fallout

Unit 11

• WHAT IS SPACE?

Where space begins and the position of the earth in space are basic to an understanding of our space program.

- Review the organization of a solar system and the positions of the planets in the system. These include the Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.*
- Refer to chart concerning planets on page 391, Brooks, Tracy, and Tropp, Modern Physical Science. Discuss with class the closest planets, the largest, the smallest, the number of moons, and the planets' distances from the earth.
- Review and discuss meteors, meteorites, fireballs, planetoids, comets, moons, and other objects in our solar system.

The earth's natural satellite, the moon, has been the object of increased study in the space program.

- Display and discuss pictures of the moon's surface.
- Discuss relationship of the moon to the earth in terms of tides, the possibility of its use as a space station, and man's attempts to study or reach it.
- Discuss characteristics of the moon (size, gravity, possibilities of life, craters, movement).

The sun, our star, has been the object of increased study.

- Show the film "Our Mr. Sun."
- Display a spectroscope, which is used to identify elements on the sun.
- Discuss relationship of the sun to the earth (sunspots, light energy, and our dependence on it).

Beyond our solar system are the great star systems of our galaxy. Beyond our galaxy is the stellar universe.

- Show by a diagram or a picture of a galaxy.

---

*Students should have a background for the study of astronomy from the Science 2 (A8) Unit concerning "Man and Space."

• SPACE

• WHAT IS SPACE?

- Show how our solar system is located in a galaxy.
- Review such related topics as the Milky Way, stellar distances, light years, star magnitudes, star classification, nebulae, supernovas, and constellations.
- Take the class on a field trip to Griffith Observatory or suggest that individuals visit the planetarium.
- Suggest that students visit Mount Palomar Observatory.

The study of space is divided into certain general areas.

- Show by a chart on the chalkboard or indicate with a globe the following classifications: (These may be modified.)

Terrestrial Space	Limited by the gravitational field of the earth to about 1 million miles
Interplanetary Space	Space in which objects are controlled by the sun
Interstellar Space	Between the stars of our galaxy
The Stellar Universe	Space beyond our galaxy

Our atmosphere, which extends for 40,000 miles, has also been divided into certain general areas for the purpose of study.

- Review the characteristics and general divisions of our atmosphere, such as the troposphere (6 miles), the tropopause (2 miles), the stratosphere (50 miles), and the ionosphere.
- Exhibit weather instruments and point out their uses in learning about our atmosphere.
- Point out how the conditions of our atmosphere differ from those of space.

Unit 11

• PROBLEMS OF SPACE

MAN'S CONQUEST OF SPACE INVOLVES MANY PROBLEMS RELATING TO TRANSPORTATION, COMMUNICATIONS, COMPUTATIONS, AND HUMAN BIOLOGY.

Concepts and Teaching Suggestions

One of the most difficult problems of space travel is leaving the earth because of its gravitational pull. If a vehicle does not reach escape velocity, it will fall back to earth or go into orbit.

- Discuss what is meant by escape velocity (25,000 m.p.h.) and gravitational forces.

Satellites stay in orbit because their outward or centrifugal force resulting from their motion is in equilibrium with the pull of the earth's gravity.

- Discuss how a satellite stays in orbit. Discuss apogee and perigee.

Great amounts of fuel are necessary for the initial thrust, but a vehicle can coast once it is in space.

- Discuss Newton's first law of motion (inertia).

- Discuss the possibility of space stations or the moon as a launching station.

Attempts to solve the problem of re-entry into the earth's atmosphere without smashing into the planet or causing the ship to burn up like a meteorite have led to the development of new materials and methods.

- Display a material like "pyroceram." Discuss nose cone research.

- Discuss the use of retro-rockets for the slowing down of vehicles.

- Discuss what other methods might be used to solve re-entry problems.

The contamination of other planets or the moon with terrestrial life, or the return of contaminated vehicles to the earth, will create a problem.

- Discuss the reasons for concern in this area.

- Discuss possible solutions to the problem.

• SPACE

• PROBLEMS OF SPACE

The rocket, which requires no external oxygen supply and functions in a vacuum, is the vehicle which produces the boost necessary to launch objects into space.

- Compare rockets with jets.
- Review Newton's third law of "action-reaction."
- Demonstrate with a water rocket or other action-reaction device.

The rocket engine is a simple device, consisting of a combustion chamber and exhaust nozzle.

- Show a diagram of a rocket motor.

Two types of systems are now used to propel rockets--liquid fuels and solid fuels. NASA's* major launch vehicles use a liquid fuel consisting of kerosene plus liquid oxygen.

- Discuss combustion of liquid fuel.
- Discuss the disadvantages of this type of fuel, especially storage of liquid oxygen, fueling, and regulations.
- Discuss the advantages and disadvantages of solid fuel.

  Advantages--simplicity, reliability, and inexpensiveness

  Disadvantages--specific impulse is only 75 to 80% that of liquid fuel

$$\text{Specific impulse} = \frac{\text{thrust X rate of burning}}{\text{weight of fuel}}$$

---

*National Aeronautics and Space Administration, the civilian space agency devoted to space activities for peaceful purposes.

• PROBLEMS OF SPACE

New types of propulsion systems are now being sought.

- Refer to some of the new types of engines which are being investigated. For example:

  The electric-arc jet, which uses liquid hydrogen as a propellant.

  The ion-propulsion engine, in which electrons are stripped from atoms and the positive ions which result are gathered and focused into a stream.

  Nuclear propulsion, in which fuel is passed through a reactor heated to high temperatures and accelerated through a nozzle.

  Photon propulsion, using light energy (photons) to push on a so-called "solar sail," or the photon rocket, which uses light energy forced through a nozzle for propelling force.

- Suggest that students report on model building projects.

Rockets which send payloads into space may have two, three, or more stages.

- Show models or pictures of various types of rockets, such as the Redstone, Atlas, Scout, Thor-Agena B, Atlas-Agena B, Centaur, and Saturn.
- Discuss use of rockets in putting payloads into the earth's orbit, and into deep space around the moon and back.
- Discuss characteristics of each type of rocket, including size, thrust, and stages.

The launching of a space vehicle demands hours of preparation and great numbers of persons.

- Show a film of a rocket launch.
- Suggest a student report on the activities involved in a countdown.
- Discuss some of the activities involved in a rocket launching, such as the necessity for teamwork, the minute details involved in checking out a rocket, and the number of personnel involved in the preparations.

• SPACE

• PROBLEMS OF SPACE

The safety problems involved in handling fuels like liquid oxygen, the precautions to protect personnel, controls of the firing, and the "panic button."

Checks on radar, weather conditions, radio frequencies, water routes, tracking systems, actual firing, and reasons for destruction of the rocket.

- Refer to some of the vocabulary of space launching.

Countdown	Loxing the bird
Retiring the gantry	Lift-off
Umbilical tower	Destruct

One of the tremendous problems of the space program is the necessity for establishing vast networks of ground stations to communicate with space craft.

- Discuss types of information relayed by satellites. These involve use of a television camera, radiation meter, micro meteoric detectors, and weather pictures. Information concerns precise location in space, and the effects of sunlight, pressure, and gravity on orbits.

- Discuss the various types of tracking, such as Minitrack, which tracks earth satellites and receives telemetered data. Others include:

  The Mercury net, for tracking space-travelling astronauts.

  The radio-telescope net, for moon missions and use in interplanetary space. (Pioneer V was tracked for 23,000,000 miles.)

  Optical Tracking, for moon tracking to establish precise information for launching vehicles to the moon. This system involves use of telescopic cameras which photograph sattelite in space.

Other problems involve computing orbits, flight patterns, influence of outer space, and many other factors.

• PROBLEMS OF SPACE

Solving of many of the problems would not be possible without electronic computers, which reduce mathematical computations to a fraction of the time that it would take men to work them out.

- Discuss how computers are used in space flight--such as for flight simulators; in the prediction of orbits, launching, and re-entry paths on the ground; and as on-board instruments to compute navigational problems and diagnose craft operations.

- Discuss the work of the programmer, which feeds into the computer data concerning all the influences on a satellite, and the computer's work in plotting the satellite's orbit.

- Discuss the value of a computer in exploring experimental theories.

NASA'S life science program in biology, psychology, and medicine is seeking answers to the question of man's survival in space, where almost everything that man takes for granted on earth becomes a problem. Experiments to find out the effects of space travel on man and to discover solutions to these problems leave an unlimited area open to man's creative thinking. One of the major areas has to do with food, water, and air.

- Discuss with students each of the following problems in space travel. (Suggest each problem as a project or subject for a report.)

Food
Water
Oxygen
Waste products

- Discuss closed-circle environments. See Appendix, Experiment 11, "Closed-System Environments," page 186.

- Display a microcosm as a closed environment. Place a goldfish in a gallon jug of water containing algae, and seal to prevent air from entering. The latter will supply O_2, and the fish will supply CO_2.

- Discuss a space menu.

- Discuss how man will be fed in space.

G-forces and weightlessness are other problems.

- Explain what is meant by G-forces.

• SPACE

• PROBLEMS OF SPACE

- Explain G-forces caused by acceleration and deceleration. Relate to earthly G-forces, such as those which affect impact in an automobile accident.
- Discuss experiments with centrifuges, spin tables, rocket sleds, and contour couches.
- Discuss the problem of weightlessness.

The problem of exposing man to radiation is constantly present.

- Discuss the Van Allen radiation belts. Show the location of these belts on a chart.
- Point out how satellites are plotting the location, extent, and intensity of rays in outer space.
- Discuss methods of combating radiation.

Psychological, physiological, and environmental factors are problems affecting man in space.

- Discuss some of the experiments related to testing these factors.
- Discuss additional problems of man in space, such as:

  Effects of lowered pressure, requiring pressurized cabins and space suit

  Temperature

  Spinning, tumbling, vibration, and noise

  The 24-hour cycle

  Sleep in space

  Anxiety, boredom, loneliness, and disorientation.

  Limitations on distance and speed of man's space travel, which include life's requirements and fuel requirements of the space capsule.

Beyond the problem of survival in space is that of survival on other planets.

- Discuss ideas which might help man to survive on another planet. Artificial breathing and a digestive system adapted to environments of the planets have been suggested.

• BENEFITS OF SPACE RESEARCH

SPACE RESEARCH IS BENEFITING MANKIND ON EARTH.

Concepts and Teaching Suggestions

Space research developments will lead to changes in our immediate environment.

- Discuss the effects of space research on the home, such as the following:

  Nose cone research--New types of kitchenware which will stand extremes of heat and cold

  Food research--New synthetic foods and better methods of packaging, freezing, and preservation

  Water research--New ways to recycle polluted water and desalt sea water

  Miniaturization of space equipment--New, more compact equipment, such as television sets, wrist radios, and other electronic equipment

  Temperature studies--New ideas for heating and cooling homes

  New materials--New alloys, plastics, and textiles

  Communications--Remote control systems

Studies of G-forces and weightlessness have provided greater knowledge which can be applied to human health and safety.

- Discuss how equipment to preserve spacemen from crushing forces will be incorporated into automobiles (body harnesses and molded seats).

  Monitoring of the heart, of brain waves, and of other physiological activities of astronauts will lead to new tools to be used in diagnosing and treating illnesses.

Hibernation studies to enable man to take long journeys have led to an understanding of artificial hibernation for pain relief, amputation of limbs, and heart operations.

Substitution of mechanical organs for human organs to enable man to explore other planets will also make it possible to replace diseased organs here on earth.

Psychological studies of man under stress will provide a greater knowledge of man's behavior on earth.

Other benefits have resulted from the space program.

- Discuss some of these benefits, such as:

  Better fuels; power plants adapted to land, sea, and air.

  Better navigation as a result of the Navy transit satellite system.

  Better communication--Telstar. Improved television and telephone transmission; swift relaying of news to all parts of the world.

  Weather prediction of high reliability, in which weather satellites are used.

Tremendous numbers of new jobs have resulted from the space program, which provides opportunities for persons of almost all aptitudes. Although many jobs demand training as engineers or scientists, much of the work is performed by individuals trained on the job or with related technical skills.

- Obtain brochures from companies or from local junior colleges offering technical training in related fields.

- Invite a speaker from a local company to discuss future training for jobs in space.

• FUTURE OF SPACE EXPLORATION

MAN'S URGE TO DISCOVER SENDS HIM TO THE NEW FRONTIER OF SPACE.

Concepts and Teaching Suggestions

The future of space exploration is unlimited.

- Point out to students some of the possibilities of the next 25 years, such as solar probes to learn more about the sun. Other possibilities include:

  Probes to Mars and Venus, with Venus as the first choice to solve the mystery of its high temperature.

  Manned satellites.

  First lunar base by 1970.

  Manned flights around the moon.

  Soft landing of a television camera on the moon.

By 1987, we expect that there will be manned space stations, lunar bases, Martian colonies, probes to Jupiter and Saturn, and the first interstellar expedition.

• SPACE

• UNITED STATES SPACE PROGRAM

AN ACT OF CONGRESS IN 1958 ESTABLISHED A CIVILIAN SPACE AGENCY, NASA (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION). ITS OBJECTIVE IS TO FURTHER THE UNITED STATES POLICY OF DEVOTING SPACE RESEARCH TO PEACEFUL PURPOSES FOR THE BENEFIT OF MANKIND.

Concepts and Teaching Suggestions

The United States space program already has achieved tremendous progress.

- Distribute a mimeographed information sheet about this program.

The following may be used for this purpose.

It would be impractical to list all the satellites now circling the globe or to make predictions, but generalizations can be made regarding the present space program. The information sheet should be revised as needed to keep it up to date.

THE UNITED STATES SPACE PROGRAM INFORMATION SHEET*

The Explorer Satellite Series--Explorer I, America's first satellite, was launched January 31, 1958, by the United States Army. It contained equipment to measure cosmic rays, micrometeorites, and temperature. It discovered the Van Allen radiation belts. Other Explorer satellites have studied cosmic dust, the Van Allen belts, magnetic fields, solar wind, and the ionosphere.

The Vanguard Satellite Series--Vanguard II was the first satellite to prove that pictures can be telemetered from great heights and that satellites can report the shape and other characteristics of the earth's cloud cover.

The Discoverer Space Probe Satellite Series--These satellites are designed to study re-entry problems.

Orbiting Observatory Series--Small instrumented packages have been launched to gather specific data, including OSO, OAO, OGO, and POGO for solar, astronomical, gravitational, and polargravitational studies.

---

*Prepared Summer, 1962.

● UNITED STATES SPACE PROGRAM

Communications Satellite Series--These satellites transmit microwaves and live television broadcasts. Echo I was the first to transmit telephone voices and still pictures. Telstar is the first active communications satellite able to transmit broad band microwave radio signals and live overseas telecasts.

Weather Satellite Series (Tiros) --Satellites in this series perform observation. Tiros I took 22,952 pictures of cloud formations and storm patterns before it became inactive.

Navigation Satellite Series (Transit) --This series is designed to assist in ship navigation.

The Spy Satellite Series (Midas and Samos) --These satellites televise views of foreign bases and rocket launchings.

The Moon Series--The Ranger will explore the moon by orbiting, taking pictures, and telemetering them back to earth.
The Surveyor will "soft land" on the moon with instruments to measure gravity, radiation, and atmosphere and to analyze minerals. It will carry a television camera. The Prospector is designed to explore a region on the moon of about 50 square miles.

The Mercury Series (Man in Space) --Satellites in this series lifted the first three astronouts into space:

Alan Shepard, Jr.	(suborbital)
Virgil Grissom	(suborbital)
John Glenn	(first United States man to orbit earth)

The Apollo Series--Satellites of this type are planned to carry three astronauts in an orbit of the moon or to serve as earth-orbiting space laboratories.

The Pioneer Series (deep space probe series) --Pioneer V was the first to go into solar orbit. It returned valuable information on cosmic rays, radiation belts, magnetic fields, solar wind, and the size of the solar system. It was the first satellite to use an interplanetary guidance system. Pioneer V returned its last message from 22.5 million miles away.

• SPACE

• UNITED STATES SPACE PROGRAM

Military projects--The Armed Forces are mainly concerned with intercontinental ballistic missiles. These carry atomic warheads and antimissile missiles. Their rockets are used as boosters for the satellite space probes.

Planet Probing Series--The Mariners will journey to Venus and Mars. The Voyagers will orbit Venus and Mars and transmit information to earth.

Dynasoar and the X-15 rocket plane program. --Vehicles in these projects will take men to the edge of space and will land by controls.

Space stations and lunar bases. --These are now being planned.

Project "Ozma" --Radio-telescopes are designed to detect signals from outer space and will help determine whether there is life on other planets.

Unit 11

• SPACE VOCABULARY

The new vocabulary of the space age is frequently used in newspaper articles and on radio and television programs.

Ask students to learn such terms as the following, which are a part of the new vocabulary of space research. Additional words or expressions may be added to the list. Copies of the vocabulary should be distributed to students when the unit is introduced.

Ablation:	Cooling a nose cone by melting of a material as re-entry temperature rises.
Aeroembolism:	Similar to the bends in deep sea diving.
Aeronomy:	Study of planetary atmospheres.
Aerospace medicine:	A new branch of medicine dealing with diseases and ailments caused by air and space flight.
AOK	"All is perfect" (from a message sent by Alan Shepard on the first suborbital flight).
Apogee:	Part of satellite orbit farthest from earth.
Artificial gravity:	Overcoming weightlessness by rotation of a space vehicle.
Asteroids:	Small planetoids which revolve around the sun, especially between orbits of Mars and Jupiter.
Astrionics (Avionics):	Combination of electronics and astronautics.
Astronaut:	Passenger in space vehicle.
Astronautics:	Science of the laws and methods of space flight.
Atmosphere:	The mass of air around the earth.
Attitude:	Position of a missile, person, or space ship in space.

• SPACE

• SPACE VOCABULARY

Ballistic missile:	Has own guidance system.
Bioastronautics:	Space biology.
Bioavionics:	Flight biology.
Biodynamics:	Biological engineering.
Birds:	Rockets, missiles, and satellites.
Booster:	First stage of a space vehicle.
Burnout:	Stage at which combustion in a rocket ceases.
Capsule:	Cockpit or chamber of a space ship.
Celestial mechanics:	Mathematical study of the motion of objects in space.
Cosmic rays:	Highly penetrating rays from outer space.
Countdown:	The process of checking a rocket before launching.
Debugging:	Eliminating defects in space equipment before launching.
Destruct:	Deliberate destruction of a space craft if it goes off course after launch.
Escape velocity:	Speed needed to escape the gravitational pull of the earth.
G-force:	Pull of gravity on a body on the surface of the earth; 2 G = twice the pull of gravity.
Guided missile:	Missile controlled from the ground.
Inertia:	Tendency of a body to keep moving once it has started.
Inertial guidance instrumentation:	Controlling the flight path of a space vehicle by using the effect of the earth's gravity on the inertia of accelerometers.

• SPACE VOCABULARY

Launch pad:	Base from which a rocket is launched.
Lift-off:	Point at which a rocket leaves its pad after developing enough thrust.
Light year:	Unit of measurement used in astronomy; distance that light travels in a year at the speed of 186,000 miles per second.
Lox:	Liquid oxygen; used in rocket propellants.
Mach:	Speed in terms of speed of sound.
Meteorites and micrometeorites:	Small solid bodies in outer space which may damage space vehicles.
Miniaturization:	Reduction in size and weight of satellite and space vehicle instruments.
Nose cone:	The protective covering on the front of a rocket.
Operational:	Equipment which has passed the research stage and is ready for actual use.
Orbit:	The revolving path of a body around another body, such as the moon around the earth.
Orbital velocity:	Velocity needed to keep a body from falling out of its path.
Payload:	Equipment which a rocket can send to a particular destination.
Perigee:	Part of satellite orbit closest to earth.
Propellant:	Liquid or solid fuel used to develop thrust in rockets.
Radio-astronomy:	Study of astronomy by means of radio-waves in space.
Readout:	Receiving of coded information transmitted from a space vehicle.

- SPACE
- SPACE VOCABULARY

Recycling:	The recovery and purification of waste materials in a space ship, especially food and water.
Re-entry:	Return of a space vehicle into a planet's atmosphere.
Retro-rockets:	Rockets fired in the direction in which a space vehicle is moving to slow its progress.
Satellite:	An object that orbits about another object; the moon is the natural satellite of the earth.
Solar wind:	Radiation pressure from the sun.
Space station:	A manned, man-made satellite with power supply, housing, and communication systems.
Thrust:	The expelling of hot gases from the exhaust nozzle of a rocket engine, thereby exerting a driving force in the opposite direction.
Telemetering:	Method of obtaining information by radio from space vehicles.
Tracking:	Determining the flight path or orbit of a space vehicle by use of optical or radio equipment from a position on earth.
Umbilical Tower:	A tower which supports lines and cables to a missile before it is launched.
Van Allen Belts:	Two concentric radiation belts around the earth.
Velocity:	The speed of an object.
Weightlessness:	Objects not subjected to gravitational force or resistance.

• TEACHER RESOURCES

CLASS EXPERIMENTS

Supplementary Laboratory Activity (See Appendix)

Experiment 11. Closed-System Environments page 186

REPORTS

Radio-astronomy
Solar prominences and sunspots
The Mount Palomar telescope
Radar - telescopes
Lunar tracking
Computers in the space age
The moon's far side
Rockets and space
Solid-propellant rockets
Food for space travel
Life on Mars
Planets and the possibility of life on them
Man-made satellites
Solar motors
Solid propellants
Space stations
Solar wind
Dynasoar
The X-15

PROJECTS

Build models of rockets and satellites.

Map the minitrack system of the world.

Build a model of a radio telescope.

Devise an experiment to demonstrate recycling.

Describe and tell the functions of United States satellites now in orbit.

Make a large microcosm.

Design a space vehicle and build a model of it.

AUDIO-VISUAL MATERIALS

Films

Fsd 629.14-6	"Space Scientist"
Fsd 629.13-33	"The Jet Story"
Fsd 551.591-4	"Unchained Goddess"
Fsd 629.133-1	"Road to the Stars"
Fsd 551.55-1	"Hurricane Hunters"
Fsd 358-2	"Air Science in Action"
Fsd 539.76-6	"The Atom and Weather"
Fsd 623.451-2	"The Corporal Story"
Fsd 629.138-2	"Destinations of Tomorrow"
Fsd 629.133-3	"Exploring the Edge of Space"
Fsd 629.138-1	"Exploring by Satellite"
Fsd 551.591-5	"Eyes in Outer Space"
Fsd 522-4	"How We Explore Space"

Filmstrips

S-161	"Information From Satellites"
S-125	"Work of Astronomers and Space Travel"
S-128	"The Canopy of Air"
S-139	"Conquest of Space" (2 filmstrips) "Earth Satellites" "I. G. Y."
S-160	"Exploring the Space Around Earth"
S-17	"Gas Pressure at Work"
S-8	"Meteorology" (3 sets) "Air Ocean" "Air Masses" "Weather"
S-73	"Weather"
S-41	"Weather and Climate"
S-72	"Our Ocean of Air"
S-86	"Jet Engines and Rockets"

Wall Chart

G-38	Astronautic Systems

- **TEACHER RESOURCES**

REFERENCES

Textbooks

Brooks, Tracy, and Tropp. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1962. pp. 310, 323, 385-439.

Pella, Milton O., and Aubrey G. Wood. Physical Science for Progress. Englewood Cliffs, N. J.: Prentice-Hall, 1959. pp. 54-65.

GENERAL REFERENCES

Honegger, Gottfried, and Peter van de Kamp. Space - The Architecture of the Universe. New York: Dell, 1962.

Viorst, Judith. Projects: Space. (Science Seminar) Washington Square Press Book.

Trinklein, Frederick E., and Charles M. Huffer. Modern Space Science. New York: Holt, Rinehart, and Winston, 1961.

Haggerty, James J. Jr. Spacecraft. National Science

APPENDIX

DEMONSTRATION TECHNIQUES

Because many students learn best from first-hand observation, demonstrations are a valuable part of instruction in Modern Science. These suggestions for lecture-demonstrations may be helpful to the teacher:

- Initiate a new unit of work with a series of experiments or demonstrations which will illustrate some of the important concepts to be learned.
- Remember that it is often valuable for a teacher to perform an experiment or parts of an experiment which the students are assigned to perform in the laboratory.
- Relate all demonstrations to the material being studied. Integrate presentations of this type with the textbook material, workbook, and laboratory activities.
- Complete all plans for a demonstration before its presentation to allow maximum freedom of thought and action.
- Gather in advance all materials, apparatus, and chemicals which will be needed for the demonstration. A checklist is helpful. Be sure glassware is clean and that apparatus is in good working order.
- If a sequence of experiments is to be performed, arrange equipment and apparatus beforehand in a neat and orderly fashion.
- Demonstrate on a large scale so visibility is not impaired. Use 8-inch test tubes, large beakers, and other large apparatus so experiments will be visible to the entire class.
- Limit the amount of equipment that will be on the demonstration table at one time. This will help provide good visibility and also will help prevent distractions.
- Try experiments in advance, but develop in the class the attitude that scientists do not expect their apparatus to work perfectly at all times. When the experiment is not successful, challenge the class to discover why.
- Be sure that you understand the operation and techniques involved in using apparatus and equipment before introducing them in the classroom. (For example, the teacher should be familiar with the oscilloscope, Van de Graff generator, and classmaster.)

- DEMONSTRATION TECHNIQUES

  - When experiments "fail," be sure that the actual cause is understood. If the reason for failure cannot be determined, quickly proceed to the next demonstration or experiment.

  - Be brief and to the point. Long drawn-out experiments will confuse rather than clarify the thinking of students.

  - Identify and explain to students materials, methods, and equipment. Provide spellings when needed.

  - Assemble or disassemble the apparatus being used in the demonstration so that students can see the essential or hidden parts. Each part should be exhibited, explained, and manipulated.

  - Remember that a demonstration should be like a good theatrical performance or sales presentation. Continue explanations, ask questions, and make comments so that the students will be aware of the principles involved while you are manipulating apparatus or pouring solutions.

  - Circulate samples of materials and chemicals in the class for inspection.

  - Obtain as much class participation as possible during each demonstration. Call upon students to smell, taste, pour, or generally assist whenever possible.

  - Perform more than one experiment to illustrate a principle. Additional experiments will help the class to grasp concepts.

  - Use simple materials (e.g., water glasses, soda straws, water) whenever possible. Students tend to be diverted by elaborate experiments and apparatus. The most simple demonstration may also be the most effective (e.g., blowing up a balloon, lighting a candle, using a water glass and cardboard to show air pressure).

  - Provide students with an opportunity to ask questions or answer them, to express ideas and suggestions, and to draw conclusions from what they observe. Ask the students to take notes and to predict results.

• APPENDIX

• DEMONSTRATION TECHNIQUES

- Plan demonstrations so that there will be sufficient time for students to discuss the principles involved. Do not crowd time.
- At the conclusion of each demonstration, return all apparatus to its proper location so it will be available when next needed. Use student help to clean up.
- Remember that surprise, humor, truth, and simplicity are valuable servants of the teacher-demonstrator. Use them.

- USE OF THE LABORATORY

A laboratory lesson requires careful organization and planning. Laboratory exercises may be conducted by individual students or small groups, depending upon the facilities and materials available and the nature of the experiments. Individuals or groups may perform the same experiment concurrently, or they may perform different experiments while working toward a common goal. Definite procedures must be established for the distribution and returning of equipment and supplies and for the development of the proper laboratory atmosphere and continual practice of laboratory safety.

Suggestions for developing the proper laboratory atmosphere--

- Establish definite rules of laboratory conduct. This may be done in a democratic fashion and should include such rules as:

  1. Work quietly.
  2. Follow all safety precautions.
  3. Do not disturb others, especially when they are conducting an experiment.
  4. Study the experiment before starting to work.
  5. Think before you start the entire experiment, as well as before you start each part.
  6. Stop and listen carefully to the instructor if he feels it necessary to talk to the group.
  7. If you are in doubt about anything, ask the instructor before you begin the experiment rather than after it is too late.
  8. When working as a group, work as a team.

- Develop among the students a desire to maintain high laboratory standards, which will permit students to work out problems and to exchange ideas regarding the problem and its solution.

Suggestions for continuous practice of laboratory safety--

- Distribute copies of Science Safety Regulations and discuss them as required by the rules of the Los Angeles City Board of Education. Orders are submitted through the science department chairman to the Business Division. (Science Safety Regulations, Stock No. 824251, 250 copies per package.)

• APPENDIX

• USE OF THE LABORATORY

- Both the student and the parent or guardian must sign a copy of the Science Safety Regulations before the student may begin any laboratory work.
- Follow laboratory safety measures yourself at all times.
- Repeatedly point out the safe practices required in the handling of chemicals and equipment and the potential hazards before students attempt a particular experiment.
- Be sure that each student knows what he is going to do and what he should look for before he begins each experiment.
- Do not have too much material available. Limit quantities for the experiment being performed to discourage unorganized experimentation.
- If experiment is performed in a group, organize to simulate an industrial team, with a leader, secretary, and other positions.

Suggestions for distributing and returning of equipment and supplies--

- Store equipment that will be used frequently in an easily accessible area. A student monitor should be responsible to see that it is removed and returned in an orderly fashion.
- Be sure that chemical supplies are clearly labeled and divided into two groups:
    1. Those that require special care in handling should be issued by the teacher.
    2. Those which are safe and used often, or currently in use, may be issued by a monitor.
- Allow adequate time for the orderly returning of supplies and equipment so that they may be checked before the dismissal bell. It should be impressed upon the individual student by group example as well as by teacher correction that he must return materials to their proper places.
- Establish the importance of having a clean and orderly laboratory for the next class.

USE OF THE LABORATORY

Suggestions for initiating student work in the laboratory--

- Discuss Science Safety Regulations and emphasize their importance.
- Point out the location of safety equipment, including the fire extinguisher and the fire blanket. Explain the use of the equipment.
- Begin to develop the proper laboratory atmosphere.
- Provide instruction in the proper techniques of assembly and use of equipment as each new type is needed.
- Teach the proper nomenclature for each new type of equipment or chemical as it is needed.
- On each day that they are in use, instruct the class or group regarding the safe handling of dangerous chemicals. Remind the students frequently of the importance of always following these procedures.
- Conduct frequent class evaluations of laboratory periods based upon previously established laboratory standards.

• APPENDIX

• SCIENCE LABORATORY REGULATIONS

EXPLANATION

The following regulations have been compiled for the safety of students receiving instruction in the science laboratories of the Los Angeles City Schools and a STRICT OBSERVANCE OF THE SAME IS MANDATORY.

A copy of these instructions is given to each student by the instructor on entering class and should be kept in the pupil's notebook and studied frequently.

Please read the following regulations, sign the statement below, and return to the instructor before starting any laboratory activity. Keep the copy of the regulations always available for reference.

GENERAL RULES

1. An instructor is required to be present during the performance of all laboratory work.

2. Follow directions exactly as given.

3. Perform all experiments carefully and in such manner as to insure safety to all persons.

4. Perform ONLY those experiments specifically designated or approved by the instructor. Unauthorized experimentation will not be tolerated.

5. ALWAYS use small quantities of materials, unless specifically directed by the instructor to use larger amounts.

6. Protect your clothing from chemicals. Clothes may be protected by a laboratory apron.

7. In case of ANY ACCIDENT, REPORT TO THE INSTRUCTOR AT ONCE.

HANDLING EQUIPMENT

1. Be sure all containers such as test tubes, beakers, and flasks are clean before using. Material left in containers from a previous experiment may cause errors in new experiments or may cause an explosion.

2. Never force glass tubing into or out of stoppers.

- SCIENCE LABORATORY REGULATIONS

3. Before cutting, heating, or using glass tubing, secure proper instructions from the instructor.
4. Before heating any apparatus, be sure all tubing and outlets are open.
5. Never point the mouth of a test tube toward your face or toward your neighbor while you are heating it.
6. Always slant a test tube when heating it and apply heat along the test tube.
7. All waste chemicals should be disposed of as directed by the instructor. Never return unused chemicals to supply containers.
8. Never taste or drink anything in the laboratory unless specifically directed to do so by the instructor.
9. Never drink out of laboratory glassware.
10. Do not pass your hand or arm over a lighted burner.
11. Always turn off burners when not in use.

HANDLING CHEMICALS

1. In case of burn from an acid, wash immediately with plenty of running water, then report to the instructor at once.
2. In case of an alkali burn (sodium or potassium hydroxide), wash immediately with plenty of running water, then report to the instructor at once.
3. Never heat or bring near a flame gasoline, ether, carbon disulfide, alcohol, or other volatile, inflammable liquids.
4. Poisonous gases such as chlorine, hydrogen sulphide, carbon monoxide, nitrogen peroxide, etc., must be generated in a fume hood equipped with suction draft and ONLY UNDER THE DIRECT SUPERVISION OF THE INSTRUCTOR.
5. Never add water to an acid (especially sulfuric acid), but cautiously add ACID TO THE WATER with constant stirring.

6. Never use concentrated acids unless specifically directed to do so by the instructor.

7. NEVER handle dangerous chemicals such as metallic sodium, potassium, red or white phosphorous. THESE MUST BE USED ONLY IN DEMONSTRATION BY THE INSTRUCTOR.

8. Never make explosive compounds or mixtures. Potassium chlorate must be used ONLY IN DEMONSTRATIONS BY THE INSTRUCTOR.

9. The preparation of a supersaturated solution of sodium thiosulphate (hypo) must be done ONLY AS A DEMONSTRATION BY THE INSTRUCTOR.

10. Explosive gases such as carbon monoxide, hydrogen, acetylene must be generated ONLY UNDER THE DIRECT SUPERVISION OF THE INSTRUCTOR.

11. The phrase "under the direct supervision of the instructor" means in the presence of, and under direct observance of the instructor during the entire operation of the experiment.

THESE REGULATIONS ARE TO BE FOLLOWED IN THE LOS ANGELES CITY SCHOOLS RATHER THAN ANY CONFLICTING INSTRUCTIONS IN TEXTBOOKS OR LABORATORY MANUALS.

• A SAMPLE LABORATORY ACTIVITY

MAKING A SIMPLE COSMETIC

The organization of the laboratory activity described in the following paragraphs must be adapted to classroom facilities and available equipment as well as to the teacher's evaluation of student needs. For example, one teacher may have valid reasons and the facilities for requiring that every student to perform the same experiment at the same time. Another teacher may have just as valid reasons for instructing groups or teams to perform several experiments simultaneously in various room locations.

The quantities in the various formulas are sometimes specified in weight and sometimes in volume. This technique provides the student with an opportunity to learn to measure weights and volumes. The formulas are also sometimes indicated in percentages to weight or volume. The teacher who does not have a sufficient number of balances will have to adapt the formulas to measurement by volume. Paraffin and beeswax may be measured in volume by holding them under water with a splint and by noting the amount of water displaced (the height that water rises in a half-filled, graduated cylinder).

PRESENTATION

It is assumed that (1) the students have already received brief instructions regarding the purpose of the experiment, the types of materials to be used, and how to measure them, and (2) simple directions adapted from the course of study or other reliable sources have also been provided. The teacher should also emphasize the importance of following the instructions to assure proper results and the maintenance of safety precautions.

Prior to the conduct of the exercise, the teacher should have instructed students to bring clean containers from home to be used as receptacles for the completed product. In addition, the teacher should stress to the class that it is important to maintain standards of personal and laboratory cleanliness.

CLASSROOM ORGANIZATION

The students are to work in teams during this activity. They are to prepare 35 gm of cold cream or cleansing cream and 25 gm of ammoniated toothpowder. Those who wish may also prepare after-shave lotion. Calculations that are to be made must be checked either by the teacher or by one of several students who have been designated to initial the correct calculations.

• A SAMPLE LABORATORY ACTIVITY

Work areas in the classroom should be assigned on the basis of facilities available. The cold cream and cleansing cream might be prepared at the counter tables, where sources of heat, stands, balances, and ice-water baths may be provided. Toothpowder may be prepared at tables in another location if balances and blenders can be made available. After-shave lotion may be made at the demonstration table, where students can use a blender and balances.

DISTRIBUTION OF GLASSWARE AND CHEMICALS

One member of each team should obtain the necessary glassware when he learns what the requirements are for the activity. A monitor may distribute the materials and assure that class members return the cleaned glassware to its proper place at clean-up time.

Whenever possible, students should have the experience of selecting the appropriate chemicals. They should learn to check ingredients before, rather than after mixing. Class members should also recognize the importance of returning chemicals to their proper places.

To accomplish these goals, it may be necessary for the teacher to place some of the chemicals (detergent, borax, paraffin, saccharin, mineral oil, beeswax, urea, diammonium phosphate, and precipitated chalk) in several labeled containers. This will eliminate crowding or waiting at the time that chemical supplies are obtained. The procedure also helps students to become more independent in performing the activity.

ORGANIZATION OF THE WRITTEN LABORATORY REPORT

Students should include the following in their written reports regarding an activity of this type: purpose of the activity, observations, and conclusions. The reports might also include the answers to a few leading questions asked by the teacher, such as:

Toothpowder

1. Why was saccharin rather than sugar, used to sweeten the toothpowder?
2. What is the purpose of the precipitated chalk?
3. Why shouldn't a more coarse material than precipitated chalk be used?

- A SAMPLE LABORATORY ACTIVITY

Cold Cream and Cleansing Cream

1. What are the purposes of the detergent and of the borax?
2. What was the cost of the cold cream that you made?
3. How much would this amount of cold cream cost in a drug store?
4. If you wanted to prepare 1 quart of cold cream at home, what materials would you need and in what quantities would you use them?

The teacher can instruct teams as well as individual students to prepare reports of laboratory activities.

ENRICHMENT ASSIGNMENTS FOR STUDENTS WHO WORK RAPIDLY AND ACCURATELY

Students who complete the activity early should be challenged to investigate other possibilities in the same area of study and encouraged to make their own suggestions. Once again, each student should know what he wants to find out, how he is going to try to reach a solution, and what he expects the possible solution to be. Before undertaking an additional activity, however, he must obtain permission from the teacher.

The teacher may make some additional suggestions to students of this type. For an activity such as the preparation of cosmetics, he might suggest:

1. Test various brands of toothpowder to determine whether they all contain precipitated chalk. Are there any coarse abrasives left after the chalk is dissolved in hydrochloric acid?

2. Determine how you could remove the scent from a rose or other flower to make perfume.

3. Visit the library to find other formulas for the preparation of cosmetics.

4. Use the Reader's Guide in the library to locate reports regarding the latest developments in certain types of cosmetics.

EVALUATION OF THE LABORATORY ORGANIZATION

The teacher should evaluate the organization of the laboratory during the conduct of each type of activity. This appraisal is more necessary in Modern Science than in other laboratory classes because of the many varied types of work, preparations, and laboratory organization. One technique which the teacher may use in evaluation is to ask himself such questions as the following:

1. Was I able to supervise and provide help when necessary to all groups?
2. Was I able to observe activities in the entire laboratory?
3. Were the laboratory activities arranged to assure maximum safety?
4. Were students able to obtain and return supplies and equipment with speed, efficiency, and safety?
5. Did the laboratory experience provide maximum learning and interest for the students?

FOLLOW-UP

Class members should discuss and evaluate their conclusions as expressed in typical laboratory reports from the standpoint of purpose, correctness of form, and accuracy of information.

• SUPPLEMENTARY LABORATORY EXPERIMENTS

The experiments listed below are described on the following pages. These laboratory activities are designed to supplement those described in the laboratory manual.

Experiment 1. THE SCIENCE LABORATORY

Experiment 2. ELEMENTS AND COMPOUNDS

Experiment 3. PROPERTIES OF ACIDS AND BASES

Experiment 4. DISTILLATION OF WATER

Experiment 5. CLARIFICATION OF WATER

Experiment 6. PREPARING A SIMPLE COSMETIC

Experiment 7. FOOD ADULTERATION

Experiment 8. COMMERCIAL PLASTICS

Experiment 9. ELECTROPLATING WITH COPPER

Experiment 10. ELECTROSTATICS

Experiment 11. CLOSED-SYSTEM ENVIRONMENTS (MICROCOSM)

• APPENDIX

• SUPPLEMENTARY LABORATORY EXPERIMENTS

Experiment 1. THE SCIENCE LABORATORY

Purpose: To become acquainted with the science laboratory

Materials: Bunsen burner, beaker, graduate cylinder, triangular watch glass, hand lens, sand, glass tubing, file, scales, filter paper

I. Parts of the Bunsen Burner

A. In your notebook, make a drawing of a Bunsen burner. Label the following parts. Under the drawing, list the parts and describe the functions of each.

1. Barrel
2. Air Intake
3. Base
4. Gas Intake Tube

B. Open the air intake and light the burner. Using a wooden splint, determine the location of the hottest part of the flame. Locate the position where there is no combustion and the splint will not burn. Make a drawing of the flame and label:

1. Area of complete combustion
2. Area of incomplete combustion
3. Area of no combustion

II. Manipulation of Glass Tubing

A. Review safety regulations

B. Cutting and fire polishing. Cut a piece of glass tubing 15 cm long, using a triangular file. Fire polish the cut ends by heating the tube with the Bunsen burner.

C. Bending glass tubing. Using a wing top on the burner, heat the center of one of the glass tubes until you can bend it to a right angle. Lay the tube on an asbestos pad to cool.

D. Making a stirring rod. Write your name on a narrow strip of paper and push it into the center of a piece of glass tubing.

Close the ends of the tubing by heating them in the Bunsen burner.

Show your work to the instructor.

E. Reporting your findings. Write in your notebook a description of what you have done in the above activity. Make drawings to illustrate the results.

III. Filtration and Evaporation

Illustrate these two important processes by performing the following:

Weigh an empty beaker and record the weight.

Weigh 2 grams of sand into the beaker.

Add 2 grams of salt to the sand.

Mix sand and salt and add 20 ml of water.

Filter the solution. Save the filtrage.

Set up a "water bath" as shown on the chalkboard.

Evaporate some of the salt solution to dryness on a clean watch glass.

Examine the remaining salt crystals with a hand lens.

Write a report of the experiment, telling what you have done and illustrating your work with labeled drawings.

Experiment 2. ELEMENTS AND COMPOUNDS

Purpose

To learn the difference between elements and compounds and how a compound may be decomposed into its elements

Materials

Mercuric oxide	Bunsen burner
Test tube	Splints

Procedure

Place a small amount of mercuric oxide in a dry test tube. Write a description of the mercuric oxide as to color and state of matter. Indicate whether it appears to be a single substance or a mixture.

Heat the mercuric oxide in Bunsen flame.* What color change do you observe?

While still heating the mercuric oxide, thrust a glowing splint into the test tube. Describe what happens. What gas has been released inside the tube?

Continue heating the tube until the powder has disappeared. Now cool the tube and examine the walls. What new material has appeared? Describe it.

Questions

Is mercuric oxide a compound or an element?

What elements were obtained when the mercuric oxide was heated?

How do the elements obtained differ in physical properties from the compound?

What is meant by oxidation?

What causes rusting of iron?

What is spontaneous combustion?

Write definitions for a chemical element and for a chemical compound.

---

*Caution: Do not inhale vapors. Mercury vapors are poisonous.

- SUPPLEMENTARY LABORATORY EXPERIMENTS

Experiment 3. PROPERTIES OF ACIDS AND BASES

Purpose

To learn the properties of acids and bases

Materials

Bottles of acids, and bases
Examples of common household acids and bases
Magnesium ribbon
Phenophthalein solution
Test tubes
Litmus paper (red and blue)
Water glass

Procedure

Read labels on laboratory bottles containing the acids and bases and list their formulas.

After testing the examples of acids and bases which are available, record results in table below.

Chemical	Effect on Red Litmus	Effect on Blue Litmus	Acid or Base
Water			
Lemon juice			
Soap			
Nitric acid (HNO_3)			
Hydrochloric acid (HCl)			
Ammonia Hydroxide (NH_4OH)			
Vinegar			
Sodium Hydroxide ($NaOH$)			
Lime water			
Clorox			

Place a small piece of magnesium ribbon in a water glass and add a few drops of hydrochloric acid. Write a description of what happened chemically.

Test a solution of sodium hydroxide with litmus paper. Add a few drops of hydrochloric acid to the solution. Test the solution with litmus paper.

Place some phenophthalein solution in a beaker. Add a base solution until it turns red. Add acid to the red mixture till the color disappears. What has happened?

Questions

What is the basic difference in the formulas for acids and bases?

What are some common household bases?

What are some common household acids?

What happens to a metal when bathed in acid?

What are the products of neutralization?

- **SUPPLEMENTARY LABORATORY EXPERIMENTS**

Experiment 4. DISTILLATION OF WATER

Purpose

To purify water by distillation

Materials

Distillation apparatus
Copper sulfate
250 ml beaker
Bunsen burner
Watch glass

Procedure

Part I

Set up distillation apparatus as shown on the chalkboard. (Copy this drawing to place with your notes.)

Place 200 ml of tap water and a few crystals of copper sulfate in the distilling flask. This blue solution will now be impure water.

Heat to boiling the copper sulfate solution, and note how the vapor is changed back to a liquid in the condenser.

Remove the first few spoonsful of water that are distilled. Then collect about 50 ml of distilled water. Taste the distilled water.

Part II

Half fill a 250 ml beaker with tap water and heat the water to boiling.

Place a clean watch glass across the top of the beaker to serve as a shallow dish.

Pour 5 ml of tap water into the watch glass.

Continue to heat until the water in the watch glass has evaporated. Examine the watch glass carefully.

Questions

How could you prepare drinking water from ocean water?

What became of the copper sulfate?

Why did you remove the spoonsful of the distilled water?

Why should cold water enter the lower end of the condenser?

What was left on the watch glass after the tap water evaporated?

Since gasoline has a lower boiling point than kerosene, how could you separate these two liquids in a mixture?

- SUPPLEMENTARY LABORATORY EXPERIMENTS

Experiment 5. CLARIFICATION OF WATER

Purpose

To remove dirt and other suspended material from drinking water

Materials

2 quart jars or large beakers
1 small jar or 400 cc beaker
1 teaspoon
1 measuring cup or graduated cylinder
soil
aluminum sulfate
household ammonia

Procedure

Fill each quart jar about 3/4 full of water. Stir a teaspoon of fine dirt into each. (Dirt with very little humus is more useful for this purpose.)

In the small jar, mix 2 teaspoons of aluminum sulfate in about a cup of water. Stir until the aluminum sulfate is entirely dissolved. Add about 1 ounce of household ammonia. (In practice, limewater is added; but, for demonstration purposes, the ammonia produces better results.)

Upon addition of the ammonia, note that a thick, gelatin-like precipitate forms. Now add this precipitate to 1 of the jars of muddy water. Keep the second jar as a control for comparison of the effectiveness of adding aluminum hydroxide to settle suspended material.

Observe that the aluminum hydroxide begins to settle almost immediately. A layer of clear water can be seen near the surface. After 5-10 minutes, the precipitate has settled and removed the dirt particles with it.

Compare results with condition of water in the control jar.

Question

What happened when ammonia was added to the muddy water?

Experiment 6. PREPARING A SIMPLE COSMETIC*

Purpose

To make a simple cosmetic

Materials

10 ml of mineral oil
5 gm of paraffin (wax)
4 gm of petrolatum (vaseline) or lanolin
5 gm of water

Evaporating dish
Crucible tongs
Graduated cylinder
Platform balance
Stirring rod
Beaker
Bunsen burner

Procedure

Mix materials in an evaporating dish and heat on a water bath (see drawing on chalkboard) until all the materials are melted. Remove from water bath and allow to cool.

Stir vigorously with stirring rod until a cream is formed.

To scent the cream, add a drop or two of perfume while stirring.

Questions

What are cosmetics?

What is the purpose of face cream?

Why is perfume added to cosmetics?

What does the word "emulsion" mean?

---

*See Supplementary Formulas, pp. 188-189.

Experiment 7. FOOD ADULTERATION

Purpose

To illustrate that various foods are adulterated.

Materials

Large beaker
Small beaker
Crucible tongs
Bunsen burner
Ring and ring stand
Wire gauze
Iron nail
Graduate cylinder
Ruler
Spoon
Butter
Peas
Coffee
Ice cream

Procedure

Perform following test on samples of foods which are provided. Describe results.

Canned peas: Place half a teaspoonful of mashed peas in a beaker containing 1 teaspoonful of water and 10 drops of HCl. Set the beaker in a dish of boiling water. Drop a new iron nail in the mixture. Boil for 10 minutes. Stir constantly. If the nail turns green, copper has been used to color the peas.

Ice cream: Test ice cream sample for presence of starch. Measure the amount of air in ice cream by measuring volume when frozen and volume when melted.

Coffee: Place half a teaspoonful of coffee to be tested on the surface of the cold water in a glass. Leave it for not more than 5 minutes. If the sample sinks, leaving a brownish trace in the water as it sinks, it probably contains a large amount of chicory. If it floats for 5 minutes, the sample contains a larger proportion of actual coffee.

Butter: Place some butter in a spoon and heat it over a low flame. If it is genuine butter, it will boil quietly with much foam. Oleomargarine and butter of lesser quality will splutter and crackle, with little foam.

Question

What happened in each of the above tests?

Experiment 8. COMMERCIAL PLASTICS

Purpose

To learn the characteristics of a few common commercial plastics

Materials

- Test tubes
- Bunsen burner
- Tongs
- Beaker
- Ring and ring stand
- Plastics
- Thermometer
- Samples of thermosetting and thermoplastic plastic

Procedure

Number samples of thermosetting or thermoplastic plastic.

Test each sample for flexibility at room temperature. Record results on data table on next page.

Place the samples in a beaker of hot water and heat to 150°F. Remove and test again for flexibility. Record on the data table which samples are thermoplastic and which are thermosetting.

To test for cementing and solubility, moisten the edge of 1 piece of plastic with acetone. Drop a little acetone on the flat surface of the other piece. Hold the moistened edges together for 2 minutes. If the two pieces stick together, the acetone has the ability to dissolve and cement one plastic. Record results.

To identify a sample of plastic, clamp a piece of plastic material in a clamp attached to a ring stand and carefully apply Bunsen flame. Note and record the type of burning, color of flame, and odor. Refer to the chart on the next page to determine whether you can identify the plastic.

Note: One of the simplest ways to identify plastics is by burning.

DATA TABLE FOR TESTING OF COMMERCIAL PLASTICS

Characteristic	Number of Sample 1	2	3	4	5	6
Flexibility of Room Temperature						
Flexibility After Heating						
Thermosetting or Thermoplastic						
Solubility in Acetone						
Odor, Color of Flame, Burning Characteristics						

TABLE FOR IDENTIFICATION OF PLASTICS

Plastic	Characteristics of Flame	Odor
Aceto butyrate (Tenite II)	White flame	Rancid butter
Acrylic (lucite plexiglass)	Blue flame	Floral odor
Cellulose--cellophane rayon	Burns well	Burnt paper
Cellulose--acetate rayon safety film	Greenish flame	Fish odor
Ethyl	Burns well after start	Sweet odor
Melamines--cataline melamine	Smoulders	Fish-like odor
Nitrate--colastic celluloid nitron	Fierce white flame	None
Nylon		Burning leaves
Phenolic--Bakelite, plaskon	Smoulders	Carbolic acid
Styrene--Lustron, Styton	Smokes	Sweet odor
Urea--Bakelite	Smoulders	Formalin odor
Vinyl--vinylite	Greenish flame	Acrid odor

Question

What are the differences and advantages between thermoplastic and thermosetting plastics?

Experiment 9. ELECTROPLATING WITH COPPER

Purpose

To learn the electroplating process and to plate an object with copper

Explanation of Electroplating

In electroplating, a thin layer of metal is electrically deposited on the surface of an object. A piece of the plating metal is made the anode or positive (+) pole. The object to be plated is made the cathode or negative (-) pole. Both the anode and the cathode are suspended in a solution of a soluble compound of the plating metal.

When a direct current of electricity is passed through the solution, the positive metallic ions in the solution are attracted to the object being plated, where they gain electrons, become neutral, and plate out as the pure metal.

The metal at the anode continues to add more positive metallic ions to the solution so that the concentration remains constant.

In copper plating, the solution used is copper sulfate, which forms the ions Cu^{++} and So_4^{--}. The anode is a strip of copper, and the cathode is an object to be plated. An electric current is passed through the solution. The Cu^{++} ions are attracted to the cathode, where they plate out. Cu^{++} ions are released from the copper anode during the plating operation, so that Cu^{++} and So_4^{--} concentration remains equal.

Formula for copper-plating solution: Copper sulfate, 35 gm; sulfuric acid, 7 ml; ethyl alcohol, 12 ml; distilled water, 250 ml. Objects to be plated may be cleaned with a hot solution of sodium carbonate to remove oil and a 3N solution of nitric acid. Refer to pp. 234 and 471, Richardson and Cahoon, Methods and Materials for Teaching General and Physical Science.

Materials

Battery eliminator (or 3 1½-volt dry cells connected in series)
Battery jar
2 clamps
2 copper wire leads
Copper strip
Copper sulfate solution
Steel wool
Paper clips
Objects to be plated (brass key, brass rod, carbon element, and similar items)

Procedure

Attach two clamps to the edges of a battery jar filled with copper sulfate solution. Place a copper strip in one clamp and hang or attach the object to be plated to the other clamp. Be sure that both the copper strip and the object are immersed in the copper sulfate solution and do not touch each other. (The object to be plated must be free of oil and oxidation, or it will not plate.)

Attach the wire leading from the positive terminal (+) of the battery eliminator to the copper element or clamp. Attach the wire from the negative terminal (-) to the clamp holding the object to be plated.

Switch on the battery eliminator and adjust current to .05 amperes or less.

Allow plating to proceed for about 1 minute. Switch off battery eliminator and examine object. If plating occurred, it should appear to be pink in color.

Dry object and buff with steel wool to obtain metallic copper color.

Repeat above operations, using different objects.

Write a description of what you have observed during the plating of each object.

Questions

Why is it necessary to have a soluble of the metal in the plating process?

What is the purpose of the metal used as an anode?

Why must the object be clean before plating? What could be other reasons for lack of success in plating some objects?

Why must the amperage be low in copper plating?

What other metals are used for plating?

Experiment 10. ELECTROSTATICS

Purpose

To demonstrate the production and detection of an electrostatic charge

Materials

Hand rubber rod	2 pith balls with attached silk threads
Comb or fountain pen	Supports (ring stand with ring)
Piece of wool or fur	

Procedure

Rub the rubber rod vigorously with the fur or wool. Bring it near a piece of paper. Describe what happens. Does the paper continue to remain attached to the rod? Explain what happens in terms of electrons.

Turn on the faucet at the demonstration desk. Adjust to a thin stream. Hold the charged rubber rod about 2 or 3 cm from the stream of water. Describe what happens.

Make a simple electroscope* using pith balls with attached strings. Attach them to ring on ring stand. Observe their behavior when a charged rubber rod is brought close to them.

Draw the position of the pith balls when they are neutral. Use the same charge as the rubber rod. Then use the opposite charge of the rubber rod.

Describe the action of the pith balls in each case.

Questions

What happens when two objects have like charges?

What happens when they have unlike charges?

What are some everyday examples of static electricity?

What are some of the dangers of electrostatic charges?

---

*If materials are available, ask students to make their own electroscopes in class. Request that they bring materials from home and permit them to have laboratory time to construct the device.

Experiment 11. CLOSED-SYSTEM ENVIRONMENTS (MICROCOSM)

Purpose

To observe what is meant by a closed-system environment

If man is to embark on space flights lasting months or even years, or if he is going to live on the moon, he will have to create an artifical environment. A closed-system environment must have a system in which water, oxygen, food, and waste products pass through an endless cycle and are used again and again. A microcosm is an example of a closed-system.

Materials

2 test tubes	Rubber corks
Small snails	Wax
Elodea	

Procedure

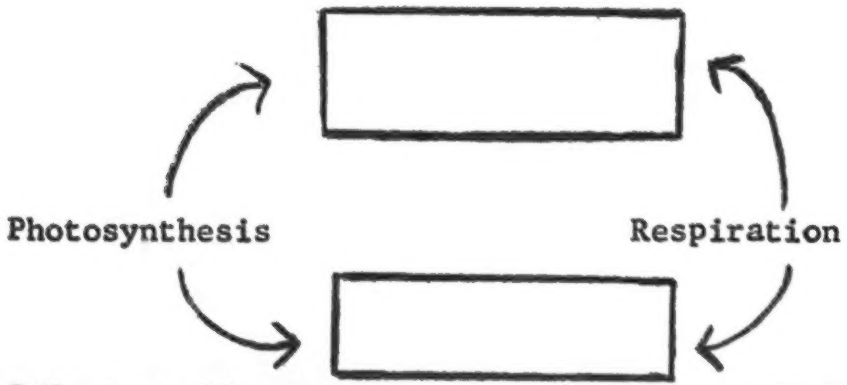
Half fill 2 test tubes with water. Place the snail and small piece of Elodea in one tube. Place the other snail in the other test tube. Seal the test tubes with adhesive tape or wax. Stand the tubes in good light but not in direct sunlight. Observe after 1 week.

Explain the following diagram:

$$6\ O_2 + 6\ H_2O \xrightarrow[\text{Green Plants}]{\text{Sun}} C_6H_{12}O_6 + 6\ O_2$$

Carbon dioxide and water

Carbon dioxide and oxygen



$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

Carbon dioxide and oxygen

Carbon dioxide and water

Describe fully the results of your experiment.

Questions

What is the "balance of nature" in a closed microcosm?

In what ways does photosynthesis provide a balance of food, oxygen, and carbon dioxide?

How are the wastes again converted into useful products?

How is this experiment related to a closed-system space environment?

How would you suggest that the factors listed below be overcome in providing a closed environment?

> Lack of protecting atmosphere and exposure to high ultra-violet rays and strong sunlight.
>
> Radiation from the Van-Allen belts.
>
> Contamination by microorganisms.

COSMETICS AND DENTIFRICES

Cold Cream

24 gm paraffin
56 gm mineral oil or baby oil
20 gm water
Few drops of detergent
Perfume to suit

Melt paraffin in double boiler. Heat mineral oil and add to paraffin while stirring. Add water with a few drops of detergent to emulsify. Stir continuously while cooling.

Face Powder

3 gm talc
10 gm zinc oxide
6 gm zinc stearate
6 gm precipated chalk
16 gm Kaolin

Mix thoroughly and sift. Add perfume and color as desired.

After Shave Lotion

5 gm boric acid
240 cc witch hazel
1 gm menthol
5 ml glycerin
Drop of oil of lavender or oil of rose for perfume

Mix ingredients. Use a blender, if available. If mixture is cloudy, let stand overnight and filter.

Nail Polish

0.3 gm eosin dye
0.3 gm zinc oxide
6 ml amyl acetates
3 ml collodion

Grind eosin and zinc oxide in mortar. Blend in amyl acetate and collodion. Mix well. Pour into test tube. Cork and allow to stand overnight.

Nail Polish Remover

30 gm ethyl acetate
90 gm acetone
30 drops olive oil or castor oil

Mix ingredients.

Lipstick

30 gm spermaceti
26 gm white beeswax
45 gm white mineral oil

Melt in beaker. Stir until well blended. Color with eosin dye. Flavor with clove, vanilla, or strawberry.

Ammoniated Tooth Powder

3 gm pwd ammonium phosphate
2 gm pwd urea
95 gm precipitated chalk

Reduce first 2 ingredients to a powder. Flavor with oil of peppermint or wintergreen and a small amount of saccharin.

Hair Cream

40 gm anhydrous lanolin
15 gm cocoanut oil or odorless castor oil
10 gm white mineral oil

Warm in evaporating dish. Add perfume as desired.

Hand Lotion

2 gm pwd tragacanth
3 gm boric acid
4 cc distilled water
5 cc glycerin
5 cc witch hazel

Stir together the first 3 ingredients and allow solution to stand overnight. Add glycerin and witch hazel last. Strain through cheesecloth. Add perfume of choice.

Perfume

Extract some of the fragrance by gently heating the petals of roses, gardenias, or lilacs in alcohol. (Use water bath.)
Caution: Do not permit an open flame near alcohol.

• SUPPLEMENTARY FORMULAS

Silvering Solution for Depositing Silver on Glass

Solution A

12.5 gm silver nitrate
32.5 gm sodium potassium tartrate

Dissolve silver nitrate in 100 ml of water.
Dissolve sodium potassium tartrate in 100 ml of water.
Mix the two solutions and heat to 55° C. Keep at this temperature for 5 minutes. Cool and pour clear liquid from the precipitate. Make up to 200 ml for Solution A.

Solution B

115 gm silver nitrate

Dissolve silver nitrate in 100 ml of water. Dilute ammonium hydroxide solution is added until the precipitate first formed is almost entirely redissolved. The liquid is made up to 200 ml for Solution B.

Mix Solutions A and B

A mirror may be made by pouring the mixed solution onto glass. The surface to be silvered should be free of all traces of grease. Pour some of the solution into a test tube to show the effect of solution in forming a mirror.

Blue Print Paper

Solution A

10 gm potassium ferricyanide
50 ml water

Solution B

10 gm ferric ammonium citrate
50 ml water

Mix two solutions together in a semidarkened room. Place in a shallow pan (glass or enamel). Float paper on the surface of the solution for a few seconds. Hang sensitized paper in a dark room to dry.

Dye Formula

0.5 gm congo red
2.0 gm sodium bicarbonate
1.0 gm sodium sulphate
200 ml distilled water

Boil fabric in dye 4 to 5 minutes.